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THE COAST AND GEODETIC SURVEY TIDE PREDICTING MACHINE No. 2.*

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One of the important functions of the Coast and Geodetic Survey is the preparation and publication of a tidal calendar, issued annually from one or two years in advance, under the name of "Tide Tables." These tables give the mariner, the engineer, and numerous others interested, information as to the time and magnitude of the tidal fluctuations of the sea. They show directly the time to the minute, and the height to the nearest tenth of a foot, of every high and low water in the year at 70 principal sea-ports of the world; and give indirectly, by means of an appended auxiliary table, the same information for more than 3,000 intermediate ports or stations.

Theory of the Tides.

While the civil calendar deals only with the positions of the important heavenly bodies, the preparation of the data for a tidal calendar involves also a knowledge of the effect upon the sea due to the force of attraction of the moon and sun. The laws governing the motion of liquid bodies under the influence of the force of attraction is well known; the tides upon a sphere covered completely by water of uniform depth could be foretold from astronomical data alone. But the continents, islands and the great difference in the depths of the oceans prevent such ideal tides, as regards both time and magnitude; so that it is necessary to resort to observation in order to ascertain the elements characteristic of each station, before the height and time of future tides can be computed.

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These observations are made mainly by means of automatic recording tide gages, in which the rise and fall of the water is made to move a pencil back and forth across a strip of paper; the latter being kept moving at uniform speed by clockwork, thus producing a continuous tide curve.

Owing to the extremely complicated nature of the motions of the moon and earth, it was practically impossible to take account of more than the most important elements in predicting tides, until there was devised, about 1867, by Sir Wm. Thomson (later Lord Kelvin) a system for the reduction of tides known as "harmonic analysis." This system assumes, in the place of the apparent sun with varying speed in an elliptical orbit inclined to the equator about 23½°, a fictitious or theoretical sun moving with uniform speed in a circular orbit in the plane of the equator, and likewise for the real moon, which moves with varying speed in an elliptical orbit inclined about 5° to the ecliptic, a theoretical moon with uniform speed in a circular orbit also in the equatorial plane. It further provides for additional imaginary bodies or components, each with its own uniform speed and period of revolution, so designed that the whole, when combined in proper relations to each other, will represent accurately the very complex motions of the real sun and moon.

All the important ones of these theoretical bodies or components were carefully determined by Sir Wm. Thomson and published in a table, later extended and improved by Sir Geo. H. Darwin, in which their speeds are expressed in degrees and fractions to the seventh decimal per mean solar hour. Each component is known by a symbol of a system of notation adopted for the sake of convenience. This table has since been used the world over by all who have to deal with tidal computations.

As these components, properly applied to the theoretical mean sun and moon, practically correct their regular but incorrect motions to the irregular actual motions of the real sun and moon, they also act as correctives to the forces represented by them, and it is permissable to regard each of them as an independent tide producing body.

Knowing the time element and consequently the period of revolution of each component, the complicated curve traced and marked into mean solar hour spaces by the tide gage can be decomposed into its harmonic elements; provided, of course, that it extend over a sufficient length of time, desirably not less than one year, so that the effects of wind storms, freshets, etc., may be eliminated.

For convenience the periods of revolution of the components are regarded as component days, and the 24th parts of these periods as component hours. The length of the component day, expressed in mean solar time, is equal to 360° divided by the hourly speed of the component, taken from Thomson's table above mentioned. A 24th part is, of course, the length in mean solar time of the component hour.

By starting from any convenient point at the beginning of the tide curve and measuring the heights of the tide throughout its length of a year or more at intervals of a component hour, we obtain all the heights at the first, second, third and so on to the 24th hour. These readings reduced to 24 means, expressed in feet and fractions, represent quite accurately the effect upon the sea due to the particular component at the station where the curve was made. In a general sense, these 24 hourly means may be regarded as representing a component tide curve. The semi-range of this curve or the height above mean sea level, is called the "amplitude" of the component, and is a constant for that station.

Were the effects of the tidal forces upon the sea instantaneous, the time of high water would always coincide with that of the meridian passage of the tide producing body. Inertia, friction, bodies of land, etc., however, retard the motion of the tidal wave, and unequally so, at different stations. The lagging of an observed high water behind the time when the tide producing cause is in the meridian may also be considered as the effect of the combined laggings of all the individual components behind their respective meridian passages. To find the lag of a component therefore, it is only necessary to determine the time from the highest point on the curve expressed by the 24 hourly means, to the instant of the meridian passage of the component. This time expressed in degrees of arc, is called the "epoch" and is, like the amplitude, a constant for the component at the station.

The amplitudes and epochs of the components entering into the tides have been determined by this analysis for practically all the important stations in the world, and have become, like astronomical data, through courtesy, exchange and publication, common property. With their aid the tides can now be computed in advance by the summation:

$$H_0 + A\cos(a\,t + \alpha) + B\cos(b\,t + \beta) + C\cos(c\,t + \gamma) + \ldots\ldots$$

in which H_0 is a constant expressing the height of mean sea level above the datum line, which usually represents the plane

to which the soundings given on sailing charts are referred. A, B, C,.....are the amplitudes of the successive components, expressed in feet and fractions, and a, b, c.....the hourly speeds of the same components, expressed in degrees of arc; t is the time in mean solar hours from the beginning of the prediction, usually January 1, midnight, to the instant for which the height is required. α is the interval from the first high water of the component A, back to the beginning of the prediction, expressed in degrees; β, γ.....being like intervals for the components B, C.....

The First Tide Predicting Machine.

Although the application of harmonic analysis to tide observations made it possible to take into account all the principal and minor components, the combination of the component elements for predicting the tides still involved a great amount of methodical work, so that the need of mechanical means to shorten and cheapen the process of predicting the tides was soon felt. Sir Wm. Thomson gave credit to "A Description of Machine for Finding the Numerical Roots of Equations," by the Rev. F. Bashford, read before the British Association in 1854, for suggesting to him a method of summing mechanically the series expressing the tidal fluctuations of the sea; and he designed and had made in 1876 under the auspices of the British Association, the first machine for computing the tides. It provides for ten components and was called by him the British Association Tide Predicting Machine. It was used but little, and later deposited in the Kensington Museum, where it now is.

The method of summing used in this machine is that of a flexible wire or chain fastened at one end and passed over and under pulleys representing the ten components; each pulley is mounted on a crank of a shaft. The eccentricity of each crank represents the amplitude of one of the components. Each shaft is made to rotate in periods of the component by means of gear wheels connected to a driving shaft common to all. The cranks are adjustable on their shafts and can be clamped in proper angular relation to each other according to their epochs. The turning of the driving shaft causes the pulleys to raise or lower the free end of the chain, which, provided with a suitable pen resting upon a strip of paper moving laterally at uniform speed, traces a curve representing the tidal fluctuations of the sea at the place and time for which the components were set.

This method of summation has been used in all the tide predicting machines constructed since. An improvement in the arrangement of the pulleys was suggested by Sir Wm. Thomson, which several years later was used in the construction of a second tide predicting machine, made for the Government of India, under the direction of Mr. E. Roberts of the Nautical Almanac Office. In this machine the component pulleys, instead of rotating on cranks in circles with radii equal to the amplitudes, are made to rise and fall in true linear harmonic motion, by means of the mechanical device, known as the "slotted yoke crank motion." (See Fig. 1.) This machine, generally known as the Roberts Tide Predicting Machine, or Tide Predictor No. 2, contains 24 components, the complicated tides of the coasts of India requiring a much closer treatment than those considered in the design of the first machine. A third tide predictor, known as No. 3, was designed by Sir Wm. Thomson and constructed about 1881. It is substantially like No. 2, except that it has 16 instead of 24 components, and that for the sake of greater rigidity, spur instead of bevel gears are employed. A copy of either No. 2 or No. 3 was made for the French Government about ten years ago, and is used in the preparation of the French tide tables. Another copy was acquired two years ago by the Government of Brazil. All these machines trace a tide curve only, which must be scaled off for obtaining the heights of the high and low waters to be made up into properly arranged tables for the printer.

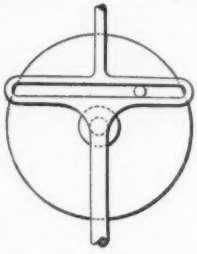


FIG. 1

THE FERREL TIDE PREDICTING MACHINE.

In 1881, Professor Wm. Ferrel, of the U. S. Coast and Geodetic Survey, designed a tide predicting machine upon principles differing materially from that of the machines before mentioned. (See Fig. 2.) The contract for its construction was given to Fauth & Co. Instrument Makers, Washington, D. C. It was completed in 1882 and was used for preparing the tide tables of the Coast and Geodetic Survey from 1883 until 1910.

Instead of tracing a curve, it indicates numerically the times and heights of the successive high and low waters by means of pointers moving over dials and scales, from which the results are copied directly upon the forms for the printer. The space

available here does not permit of making clear how the principals underlying its structure are carried out. Suffice it to say that the principal lunar component is set up in the machine as the standard. The other components, moving at speeds equal

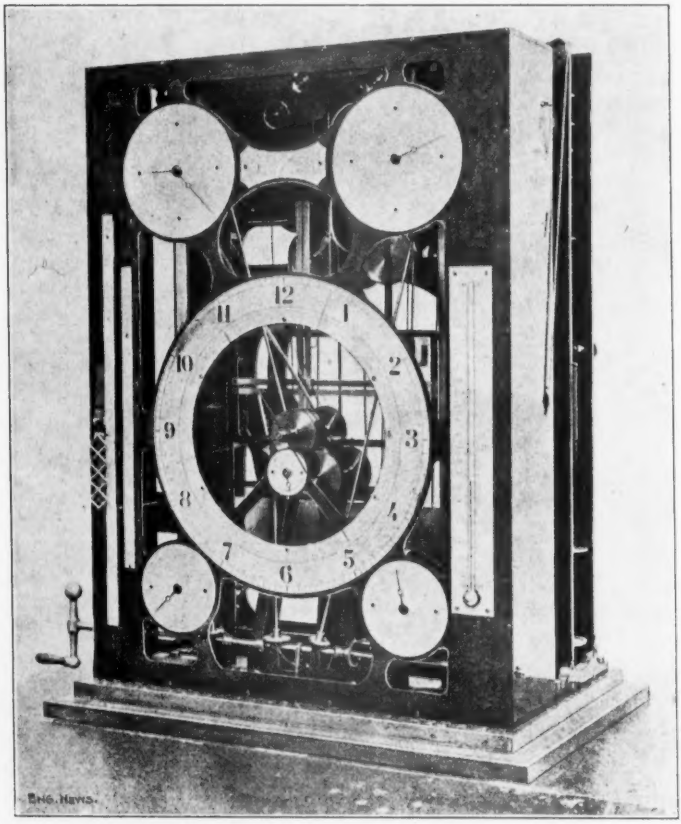


FIG. 2. FERREL TIDE PREDICTING MACHINE.

to the differences between their speed ratios and that of the mean moon, are provided with two cranks fixed at right angles to each other, one set of these cranks summing the cosine series for heights and the other the sine terms of the first derivative of the cosine series for the times of the tides.

By an ingenious device producing mechanically the triangle representing the sums of the cosine and sine terms, an oscillating needle is made to add or subtract the angle by which the pointer representing the mean moon is in error of the real moon. Theoretically considered the machine requires separate settings for the heights and times, though practically, for the simpler tides, as those of the eastern coast of the United States and the western coast of Europe, a single setting is made to suffice. As the machine was designed to be set upon a table or desk, its dimensions as a whole (18 ins. × 14 ins. × 24 ins.) necessitated those of its parts, as pitch and diameter of gear wheels, diameters of shafts, etc., to be such as failed to provide sufficient rigidity, when set up with amplitudes for tides of the larger ranges. Also, in the case of the more complicated tides, the triangle representing the sums of the sine and cosine terms frequently becomes so small that the mechanical device fails and requires the operator's attention and assistance in order to obtain accurate results. Twelve years almost constant use had caused considerable wear. For these reasons it was deemed advisable to replace it by a new machine, which should be most comprehensive, accurate, rapid and durable.

Coast and Geodetic Survey Tide Predicting Machine No. 2.

In the light of the experience gained from the previous machines as regards the theory involved, the problem of designing such a machine had become largely a mechanical one. The writer, who, while in the employ of Fauth & Co., had made under the immediate direction of Professor Ferrel, the working drawings and constructed with his own hands the Ferrel machine, and had later been called to take charge of the instrument work of the Coast and Geodetic Survey, was entrusted with the planning, designing, and constructing of a new machine, which should possess the desired properties. His plans were accepted by the Instrument Board of the Survey in 1895, and the work of construction was begun in 1896. Only such time as could be spared from the regular and the more pressing work of the instrument shop could be utilized, and for about three years a reduction of the force of employees made it necessary to suspend work altogether. So that it was not until February, 1910, that the new machine was completed and could be used for the prediction of tides.

In making the first plans for the machine, the following requirements were held in view: It should, like the Ferrel machine, indicate the results numerically for direct copying upon the forms for the printer; it should indicate, with only one setting of the components, not only the times of high and low waters, but also the heights at any instant; the height amplitudes should be 1/24 of actual size, or on a scale of ½-in. to 1 ft; it should produce automatically, for purposes of record in place of the duplicates of the printer's copy, a true tide curve for a length of one year, upon scales of from 1:15 to 1:120. marked off into hour spaces of ½-in. per hour, or 1 ft. per day; it should provide for 37 components.

Before deciding upon the general form of the machine, the writer studied exhaustively the subject of mechanical summation, with the hope of improving upon the chain and pulley; but all the methods suggesting themselves, when considered in detail, led back to that as the simplest method of summing harmonic series.

The fact that the sum of a harmonic series of cosine terms is either a maximum or a minimum when its first derivative becomes zero, was already made use of in the Ferrel machine for finding the time of high and low water, by fitting each component shaft with two cranks, one for the cosine summation and the other for sine summation, at right angles to each other. The same principle was applied in the new machine, as proposed by Dr R. A. Harris of the Coast and Geodetic Survey. The series

$$H_0 + A\cos(at + \alpha) + B\cos(bt + \beta) + C\cos(ct + \gamma) + \ldots\ldots$$

is summed on one side of the machine for the heights (Plate X), the free end of the chain being made to indicate by a pointer upon a dial, the height of the tide at any instant in feet and tenths; and at the same time to impart vertical motion through gearing adjustable to different scales, to a pen tracing the record tide curve. The cranks on the opposite side of the machine (see Plate IX, Frontispiece), at right angles to those summing the cosine series, sum the sine terms in its first derivatives: $Aa\sin(at + \alpha) + Bb\sin(bt + \beta) + Cc\sin(ct + \gamma) + \ldots\ldots$ The movement of the chain representing this summation is in view of the operator. When the zero link of the chain comes under a fixed index, the pointers on the day, hour and minute dials show the time of the high or low water indicated by the

PLATE X.

C. & G. Survey Tide Predicting Machine No. 2:
HEIGHT SIDE.

pointer on the height dial. The amplitude scales of the sine cranks are graduated into units in accordance with the requirements of the derived series, but the amplitude settings of both cosine and sine cranks, while different in actual length have numerically the same number of units.

[Just how the pulleys and chain act may be seen from Fig. 3. Suppose one end of the chain fixed at F, and passed over the pulley A. The disk A is made to rotate and the crank then gives to the yoke A a true linear harmonic motion, raising and lowering the pulley A. Suppose the disc B fixed so as to have no rotation. The free end of the chain P then traces the true harmonic curve C_1 upon a strip of paper passed under it at a uniform rate of speed. Suppose now that the disk B rotate with its given amplitude and epoch setting and the disk A be kept motionless. A harmonic curve represented by C_2. will now be traced on the paper. If the two disks A and B be allowed to rotate simultaneously the sum of the two curves C_1 and C_2, represented by C_3, will result. Similarly any number of component harmonic curves may be combined.—Ed. *Engineering News.*]

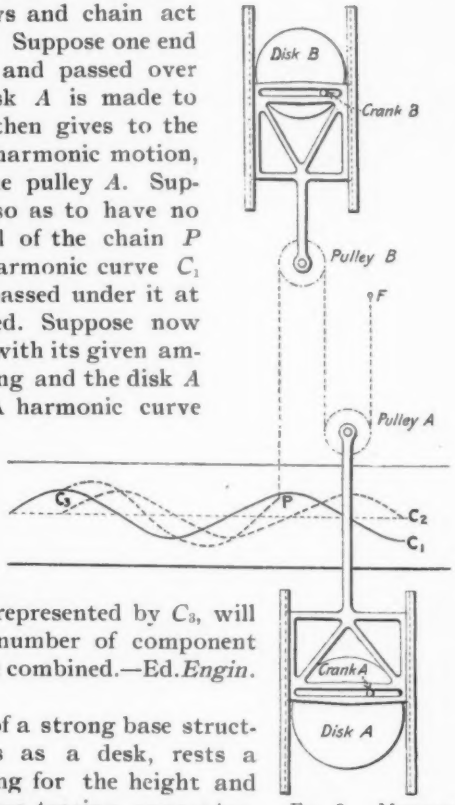


FIG. 3. METHOD OF MECHANICALLY ADDING HARMONIC MOTIONS.

Upon the front part of a strong base structure, which also serves as a desk, rests a case housing the gearing for the height and time dials and the curve tracing apparatus. It is composed of two hard rolled brass plates 5/16-in. thick, 19 ins. wide and 24½ ins. high, secured to each other 6 ins. apart. Upon its front is mounted the required height scale of 10, 20 or 40 ft., subdivided to tenths of feet. Within this ring are mounted two dial rings, the one on the left graduated to 24 hours, and that on the right to 60 minutes. Immediately above these is a curved opening exposing part of the day and month dial revolving

within the case, the days being pointed out by an index on the plate. Up on the space above these dials is exhibited, for a lateral distance representing 26 hours, the tide curve traced upon a strip of paper 6 ins. high, which issues from a slot on the right side, passes across and enters the case through a slot on the left side of the face. At the right side an adjustable fountain pen is mounted on a carriage with vertical motion for tracing the record curve. Immediately adjacent is mounted another fountain pen, adjustable to a correct fixed position, for tracing the line representing mean sea level. (See Plate X.)

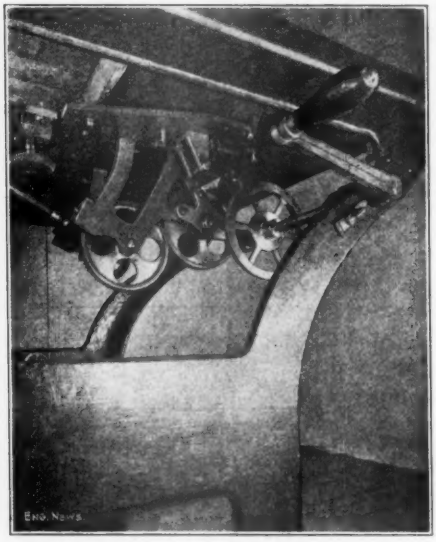


FIG. 4. DRIVING CRANK.

Immediately behind the dial case, upon a depression of the base, 18 ins. from the floor, is mounted a frame, made up of two hard rolled brass plates 11/32 in. thick, 24 ins. wide and 56¼ ins. high, held 7 ins. apart by ¾-in. round posts, in which are mounted the shafts of the larger components and their mechanisms. Behind this, on a part of the base 25¾ ins. from the floor, is placed the frame accomodating the remainder of the component shafts and their mechanisms. The thickness of the plates and the space between them are the same as those of the other frame. Its height is 40¼ ins. and the length 56¼ ins.

A crank at the left side of the desk (Fig. 4) is geared to an

inclined shaft, which at its upper end connects by conical gears with a vertical driving shaft mounted at the rear of the front section of the frame. (Frontispieec.) By spur gears connection is made with a similar vertical shaft in the front of the rear section of the frame, which in turn is connected by a horizontal shaft and conical gear wheels to a third vertical shaft at the rear end. A fourth vertical shaft (Fig. 5), within the dial case, is driven through conical gears and intermediate shafts by the inclined shaft below the desk. All these vertical shafts revolve once in three turns of the crank. Those in the component frames impart motion, through intermediate shafts and two pairs of conical gears, to the component shafts.

The vertical shaft within the dial case drives, by means of two pairs of conical gears each, the pointers of the 24-hour and 60-minute dials, and, by means of two conical gears and a worm-screw gearing into a worm wheel with 366 teeth, the day and month dial. The ratios of these gears are such that all the vertical shafts make two revolutions when the 24-hour pointer makes one, or indicates one day.

A special device provides for the extra day of leap years. A small pointer under the index pointing out the days, when thrown over to the words "Leap Year," causes the index to remain stationary when the 29th of February passes by; but, when thrown over to the words "Common Year," the index jumps over to March 1, when the 28th of February has passed. (The plates with the legends had not been mounted when the photographs were taken.)

From the upper end of the vertical shaft within the dial case motion is imparted, by means of spur gears 1:1, through a ratchet stud gear, to the feed cylinder of the curve tracing apparatus. This cylinder has a circumference of 6 ins. and is fitted near its ends with fine needle points. This unwinds and pulls across the front of the face a roll of bond paper .0024-in. thick, 6 ins. high and 380 ft. long, mounted on a friction shaft on the right hand side, and rewinds it upon a receiving roller on the left of the case, by means of a friction sprocket and chain drive. The paper moves at the rate of 12 ins. per revolution of the 24-hour pointer. The ratchet stud gear leaves the paper at rest when the machine is turned backwards. When desired the paper feed can be thrown out of action altogether by the turning of small button on the rachet stud gear.

The component shafts are made of steel 5/16 in. in diameter and run in hard cast iron bushings riveted to the plates.

The cranks are of hard cast brass and have perpendicular slots milled through them, for clamping the steel crank pin at any

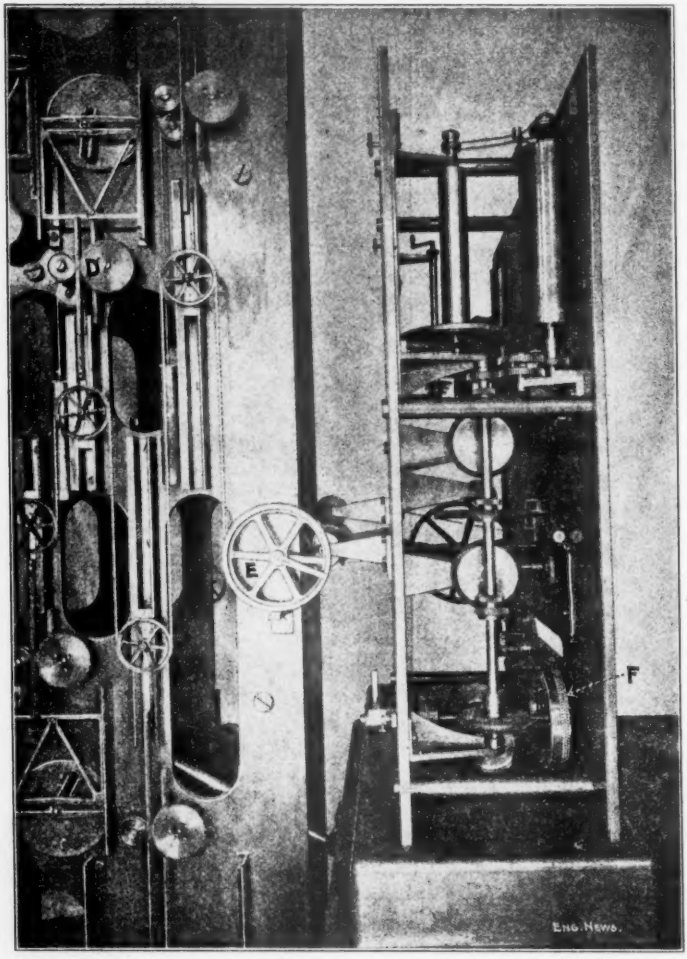


FIG 5. DIAL CASE: HEIGHT SIDE.
D. Rack and Pinion for Doubling Motion.
E. Weight Chain Wheel.
F. Time Chain Wheel.

point. The crank pin is fitted smoothly into a hardened steel block which moves freely in the horizontal slot of a light steel frame, 1/16-in. thick. The steel frame is confined in the grooves

of two vertical guides and connected by a slender strip of steel to the steel slide carrying the chain pulley. The pulleys have a diameter of 2 ins. measured on center of chain.

The chain pulley slide moves in a brass guide piece, one side of which is widened to accomodate the amplitude scale and its numbering. An adjustable index is secured to the pulley slide for reading this scale. Each component crank carries a pointer by means of which the epoch is set off upon a graduated circle mounted against the plate immediately behind the crank.

The slowest five components are driven by one pair of gear wheels and a worm screw and worm wheel; they are provided with short auxiliary shafts and gearing for disengaging and quickly setting the epoch. Each of the component shafts can be released, set to its proper epoch and firmly secured in place, by screwing down a clamp nut, forcing a dished and split washer or disk against the edge of a recess turned into the gear wheel on the vertical driving shaft. Each of the vertical driving shafts can be clamped to avoid disturbing one setting by another.

The scale of ½-in. to 1 ft. adopted for the height amplitudes required lengths for the cranks which could not be accomodated within the space to which the machine had to be restricted. The largest component, for instance, that representing the mean moon, requires a crank 10 ins. long, if set to its maximum amplitude. To save space two components were provided in place of 1, and the motion of each of the two steel frames was doubled by means of a rack fastened to it, which gears into the smaller of two gear wheels with ratio of 1:2. Another rack fastened to the pulley slide is geared into the larger wheel. This allowed of the use of 2½-in. cranks in the halves of the principal lunar component. In the same manner three other components were accomodated, while a number were reduced in size by the use of doubling gears alone. Counterpoise weights are provided for the upper row of double-geared components for balancing the weights of the racks. (See Fig. 5.)

The ratios of the gear wheels conveying motion from the vertical driving shafts to the component shafts are simple arithmetical expressions of the speed ratios given in Thomson's table, obtained by trial factoring. They have been worked out a number of times in connection with the earlier machines built. Quite a number of the speed ratios being expressible in more than one combination of the four wheels, the writer was able by recomputing them, to arrange the components as to their location so as to reduce considerably the dimensions of

the machine as a whole. The ratios as employed are correct to a small fraction of a degree per year; that is, the epoch settings are correct within one or two tenths of a degree after running the machine through a year as indicated on the dials. In arranging the location of the components care was taken to place those with the largest amplitudes and highest speeds nearest to the source of power, as far as the dimensions of their parts would permit. The product of the speed into the amplitude was taken as a measure in the selection of their positions.

The left side of the machine, facing the dial case, carries the height or cosine cranks; the right the time or sine cranks. At the rear end on the left side is the fixed end of the height chain, fastened in such manner as to permit of its being let out or taken in by an inch or so for accurate adjustment. The chain is of the chronometer fusee type, of tempered steel, 0.1-in. wide and 0.05 in. thick, and has 125 links per foot. It passes under and over all the height pulleys of the rear frame; is led across the space between the rear and front frames by means of two stud pulleys, and over and under the height pulleys of the front frame. Leaving the last of the pulleys it is fastened to a thread grooved wheel 12 ins. in circumference, about which it is wound by means of a counterpoise weight suspended within the frame. (See Fig. 5.) When all the height components are set to zero amplitude, half of the threads of this chain wheel are filled with chain, and an index secured to it coincides with an index fastened to the plate. The total length of the height chain is 27 ft. 7 ins. the load on it due to the counterweight is 6 oz.

The chain wheel is mounted on a shaft which carries a grooved wheel 2 ins. in diameter holding the chord of the counterpoise weight. By means of two spur gears with a ratio of 30 to 100, motion is imparted by this shaft to another secured to the rear of the dial case, which, by a pair of miter gears, moves the pointer of the height scale, clockwise, indicating rising water, when the effect of the components is to to take in chain, and counter clockwise, indicating falling water, when chain is let out.

Upon the shaft carrying the miter gears for giving motion to the height pointer is also mounted a set of three change gears, by means of which a short shaft with a chain wheel 4 ins. in circumference can be moved at ratios of 1:1, 2:3 and 1:2 A chain secured to this wheel passes through the dial case around a pulley, upward and through a clamp in the pen

carriage, and over another pulley through the front plate to a counterpoise weight, thus connecting the curve pen positively with the height chain pulley.

The summation chain on the time side of the machine, from an adjustable fastening in the extreme rear, passes under and over all the time pulleys in the same manner as that of the height chain, until it leaves the last component pulley, whence it is led around a stud pulley secured to the base, forward around another under the desk, up through the desk into the dial case and, having now made a quarter-turn, over another stud pulley across the dial case immediately behind its face, to the time chain wheel, which runs in bearings in the plates. A counterpoise weight, rising and falling below the desk is provided as in the case of the height chain wheel for taking in the slack chain. When all the sine or time cranks are set to zero amplitude the time chain wheel is half filled, and a platinum point on the chain, marking its zero, is in contact with a platinum tipped index in the middle of a horizontal opening in the face of the dial case. The length of this chain, measured to the platinum point, is 27 ft. 1 in., the total length being 30 ft- 7½ ins.

The fixed fountain pen provided for tracing the base line is mounted on a shaft carrying the armatures of two pairs of electromagnets. The upper pair of these magnets is in circuit with a battery and a contact spring resting upon a rubber wheel secured upon the shaft carrying the 24-hour pointer. In the edge of this rubber wheel are imbedded 24 platinum strips representing the hours of the day, the 24th hour being marked by a double strip. When rotating, successive contracts are made, which throw the base line pen downward, thus marking off the hour spaces, midnight being indicated by a double mark.

When the platinum point on the time chain comes in contact with the platinum tipped index, another electric circuit is closed, causing the lower pair of magnets to throw the base line pen upward for an instant, thereby marking the time of each high or low water.

In order to relieve the operator of the strain incident to watching for the exact moment when to stop the machine, for copying off its face readings of high and low water, a third electric circuit is provided, by means of which the machine is stopped automatically at the instant when the zero point of the time chain marks a high or low water. This is accomplished by an electro magnet under the desk, which, when the circuit

is closed by a contact device on the rear end of the shaft carrying the time chain wheel, throws down a ratchet pawl upon a fine-toothed ratchet wheel secured to the driving crank shaft. The circuit is led through the arm of the driving crank, and can be broken by a slight, momentary inward pressure against the crank handle, thus releasing the ratchet wheel and allowing the machine to be turned on to the next stop. Cut-out switches for this and other circuits are also provided.

With the amplitude and epoch table, taken from the files, in hand, the operator prepares the machine for predicting the tides for a station. The three vertical driving shafts are clamped. Each component is released by loosening with a pin wrench the clamp nut of the gear wheel on the driving shaft; using this gear as a milled head, the crank is set in a vertical position pointing towards its chain pulley; with a milled head wrench the crank pin is released, moved until the index on the pulley slide indicates upon the amplitude scale the amplitude setting for the component, and re-clamped; the crank on the opposite side of the machine is then set vertical and its amplitude set in like manner. The component shaft is then turned until the pointer on the crank indicates upon the degree dial the degrees and tenths of the epoch, after which the clamp nut on the gear wheel is tightened. This is done for all the components entering into the tide to be predicted. All those not required are set to zero amplitude, which leaves their pulleys at rest and, consequently, out of action.

The vertical driving shafts are then unclamped and the day, hour and minute dials set Jan. 1, 0 hour, 0 minute. After this the machine is turned until the index on the height chain wheel indicates the sum of the height components to be zero and therefore represents mean sea level; in which position the pointer on the height dial is set to the height representing the plane, usually mean low water, to which the tides in the tide tables are referred. The machine is then turned back to the position indicating Jan. 1, 0 hour, 0 minute.

A new roll of paper having been mounted, the pens filled and the electric switches thrown in, the machine is ready for predicting. The operator, sitting at the desk, has before him the printed blank form; with his left hand he turns the crank until it stops; he copies from the dials the hours, minutes, feet and tenths indicated by their respective pointers, the day of the week and the month being already given on the blank in print. He then pushes the crank handle inward and turns the crank until it is again arrested by the stopping device, and so on.

The time required by one man for setting the machine varies, according to the number of components used, from about 2½ to 4 hours; that for the prediction of one year's tides ready for the printer from about 8 to 15 hours.

The degree of accuracy of the predictions was thoroughly tested by setting the machine for two stations with tides of a nature most likely to reveal faults of design or construction. The stations selected were Aden, Arabia and Hong Kong, China. The number of the components used in the first was 35, and the latter 33. The machine was run through nearly a year before 24 hourly heights were read to hundredths of a foot. The comparison of these heights with those obtained by careful computation showed a maximum difference of 0.02 ft. in the case of the Aden tide, and 0.06 ft. in that of Hong Kong.

BIBLE ASTRONOMY.

S. C. HUNTER.

It is supposed that Moses wrote the book of Genesis about 1600 B. C. Whatever the world's sum of astronomical knowledge may have been at that time is of course purely a matter of conjecture. It is certain, however, that the educational advantages Moses enjoyed in the astronomical line, or in fact in any other line, were far beyond the ordinary. As the adopted son of the daughter of the reigning Pharaoh we are told he was "instructed in all the wisdom of the Egyptians," and consequently he had at his command for a period of forty years the accumulated learning of what was at that time the most progressive and erudite court in the world. There is a lot of uncertainty after all, concerning the actual beginning of astronomical lore. Almost as far back as we can find records of anything there appears here and there some mention of this interesting subject, which would seem almost to warrant the belief that from the earliest coördination of man's observing faculties the stars excited wonder and admiration. It appears fairly certain for instance, that the Chaldean Astronomers as early as 4000 B. C. were interested in tracing the sun's path among the stars, and that the constellation of Orion was a recognized asterism in the Euphratean valley as early as 3385 B.C. These dates carry us many hundred years beyond Moses' time, and it

may be stated with considerable assurance that the fragmentary knowledge gleaned by modern discovery from the ancient inscriptions, point to a familiarity with astronomical matters that justifies our feeling that there was more known by the early civilizations than we are able to trace at this distance. It was not until at least 1000 years after the writings of Moses that astronomy assumed the dignity of a real science, through the genius of Thales, chief of the seven wise men of Greece, so that prior to his time there was apparently nothing more reliable than the observational knowledge of each tribe or nation perchance recorded. Well may we ponder then the majestic dicta of the first chapter of Genesis and wonder if after all anything has been written since, that is altogether more comprehensive and convincing concerning the Creative impulse.

Here we have a definite plan of celestial creation—it can hardly be called a theory—which has withstood the assaults of generations of critics—written by a man whom we must classify as an unusual genius, and whose holiness justified the distinction of a "face to face" acquaintanceship with Jehovah. Since his story was written various theories have had their day; but in the light of new discoveries none of them have been final, and even at this time of highest astronomical efficiency the moderns have nothing to offer which affords a firm and conclusive foothold.

While therefore we may smile with pitying toleration at the man who maintains that God created the Heavens and the Earth, the conclusion cannot be avoided that the burden of negative proof rests still upon the shoulders of the unbeliever.

The reference already made to the Chaldean astronomers and their acquaintance with the zodiacal constellations is doubly interesting in the light of the fact that Abraham was credited with a Chaldean origin. Out of Ur of the Chaldees he came at the command of Jehovah. Thus we have the great progenitor of the Israelitish nation coming out of the country that we associate with some of our first records of astronomical knowledge. Abraham was chosen to head a nation that should reveal a certain type of monotheism to mankind. He was promised countless descendants; but at a time which he deemed critical he found himself without offspring and became discouraged and even skeptical of the intentions of Jehovah. On a certain night, we are told in the Bible story, he was admonished by the gentle suggestion to look up into the heavens, and number the stars if he were able to do it, for so would his seed

be. The challenge to number the stars did not mean then what it means to us now. There were no aids to ordinary vision. If Abraham had actually taken the time to count the visible stars perhaps 3000 would have rewarded his patience. No doubt to his wondering eyes they did however seem countless and if he could have foreseen the knowledge brought to us today by our great instruments, and realize that even 100,000,000 stars may scarcely express the numerical strength of the heavenly host, he doubtless would have been filled with rejoicing and his dejected soul illuminated by the Divine prediction.

Sabianism or star-worship forms an interesting chapter of astronomical study. To what extent it prevailed among the Euphratean nations it is difficult to determine, but it certainly appears almost full fledged from the very beginning in the Egyptian records. Temples were apparently oriented to the brighter stars and asterisms at a very early period. Everyone recalls the familiar figure of the Egyptian God Anubis—a man's body bearing a dog's head. This we learn was intended to symbolize the great dog star Sirius and we find it was deified and worshipped in the Nile valley long before Rome was heard of. In fact it is known with a fair degree of certainty that Sirius was worshipped as early as 3285 B. C., when its heliacal rising at the summer solstice marked the Egyptian New Year and the beginning of the Nile inundation. The name dog star seems traceable to what was supposed to to be the watch dog function of this star in heralding the Nile innundation, although now because of precession this heliacal rising is carried along to August 10. Perhaps no single star throughout the ages has attracted so much attention as this one and no wonder, for it is now as it ever has been, the brightest and most compelling star in all the vault of heaven. We may easily believe then that at least seven Egyptian temples were oriented to it.

The Israelites, although retaining a separate identity as a people, were Egyptian subjects from the time of Joseph until the exodus—a period of four hundred years. Jehovah was their God and doubtless in the main they worshipped him, but other ideas of worship, and the knowledge of other Gods must have been gained at this time, as shown by their repeated backslidings during the wilderness journey. It is quite conceivable that the mysteries of star-worship were among the idolatries acquired. The evidence in Deuteronomy seems indeed quite conclusive on this point, as we find in a passage in the fourth chapter that it became necessary for

Moses to exhort Israel to observe God's Law, and to avoid the danger of being drawn away by the worship of "the sun and the moon and the stars, even all the host of heaven."

And later, in 638 B. C., when the young king Josiah came to the throne of Judah, it is recorded in II kings that the idolatrous priests that burned incense to the sun and the moon and to the planets, and to all the host of heaven, did not escape the purifying besom of this righteous monarch, for they were summarily put down, and the horses that had been given to the sun by previous kings were taken away, and the chariots burned with fire.

The writer of the book of Job seemed to have a surprising familiarity with celestial matters. The book is still shrouded in mystery and the writer quite unknown, but the fact that the hero Patriarch of the story resided in the land of Uz helps us to understand the references to astronomy, for this place has been identified as being adjacent to the territory of the Sabaeans and Chaldeans and it is therefore not surprising that the best known asterisms were introduced with facility in the ordinary dialogue of the story.

So little is actually known about this classic that when we are told it was written somewhere between 500 and 450 B. C., we know at best this must be a mere deduction from comparative evidence, and yet it is interesting to remember that this would bring the writing in line with whatever astronomical lore was available to the Greek Thales, who was busy at about this same time making a science of existing star knowledge. We read of the Pleiades, Orion, Bear and Zodiac as if these names were as familiar to the people for whom the book was written as they would be to a twentieth century audience. It is not likely, however, that the questioner impersonating Jehovah in the 38th chapter, ever thought the time would arrive when an accurate reply could be given to the question "Hast thou comprehended the earth in its breadth," any more than he expected poor Job to perform the impossible feat of binding the cluster of the Pleiades, or loosening the bands of Orion. And yet today the "ordinances of the heavens" are as familiar to us as the breadth of the earth. Indeed what are the secrets of the universe that are held secure against the prying investigation of this and future generations? We thought only yesterday that with the telescope, photography and the laws of gravitation our tools were sufficient, but with the possibili-

ties of the study of light with the spectroscope, is it not true that astronomical inquiry is now destined to reach out into realms that were hardly dreamed of only fifty years ago?

That dear old friend of all amateur astronomers, the Rev. T. W. Webb, whose wonderful legacy of star data must always remain a classic, chose for the inscription to his second volume of "Celestial Objects," the beautiful 26th verse of the 40th chapter of Isaiah, and was no doubt guided in this choice by the instincts of a devout astronomer. "Lift up your eyes on high, and see who hath created these, that bringeth out their host by number; he calleth them all by name; by the greatness of his might, and for that he is strong in power, not one is lacking." Just how far the Creator may be responsible for the names o the stars must remain an open question, but if Isaiah's statement that "he calleth them all by name" was the prophetic announcement of a time when every star would have its separate designation, it came pretty near being a correct forecast of the accomplishment of this present generation.

The Old Testament Prophets in all probability wrote of things suggested by the incidents of their daily observation. With this idea in mind it is interesting to recall the eclipse of the sun which we are told is mentioned in the Assyrian records as having occurred on June 15, 763 B. C.

This phenomenon might easily be associated with the 8th verse of the 5th chapter of the Book of Amos, which reads as follows:

"Seek him that maketh the Pleiades and Orion, and turneth the shadow of death into the morning and maketh the day dark with night."

Amos wrote between 800-750 B. C. Would it not be fair to speculate on the probability of the prophet having been an actual eye witness of this occurrence? How truly would an eclipse of the sun suggest making the day dark with night. Literature contains many instances of the mental effects of an eclipse, and the idea often conveyed is one of a gruesome darkening, and a turning of day into night. The prophet's mission was to threaten Israel with disaster. Here was a visible example of what the Lord Jehovah could do. Again we notice in this verse a familiarity with the two great asterisms. Reference has already been made to the probable antiquity of Orion, but it would appear that the Pleiades are the first stars mentioned by name in astronomical literature, and are found in the Chinese Annals of 2357 B. C.

The great star puzzle of the New Testament is the identification of the star of Bethlehem, also the wise men that followed its beckoning finger.

Whether the latter belonged to the Priestly cast in Persia and were astrologers of the Zoroastrian religion, or were simple Arabian seers will never be known. There was a remarkable conjunction of planets in 747, year of Rome, which would attract the notice of astrologers, and which, although it would be too early for the visit to Bethlehem, might correspond with the first appearance of the "Star". The only alternative is to adopt the suggestion of a supernatural appearance. Volumes have been written on the subject. Recalling the Bible story, however, one may easily imagine he has seen a close copy of this mysterious visitor when he beholds the supernal beauty of the planet Venus hanging low in the eastern sky in the early morning hours. Is it not also a noteworthy coincidence that a star heralded the birth of the Christ Child, and away back in the misty past it appears as the symbol for God in the cuneiform inscriptions of the earliest nations?

Finally, it is surely the Psalmist who has happily succeeded in stating the answer to the question, with rare insight and poetic inspiration, which must forever pervade the consciousness of the reverent astronomer, in the beautiful words of the 8th psalm.

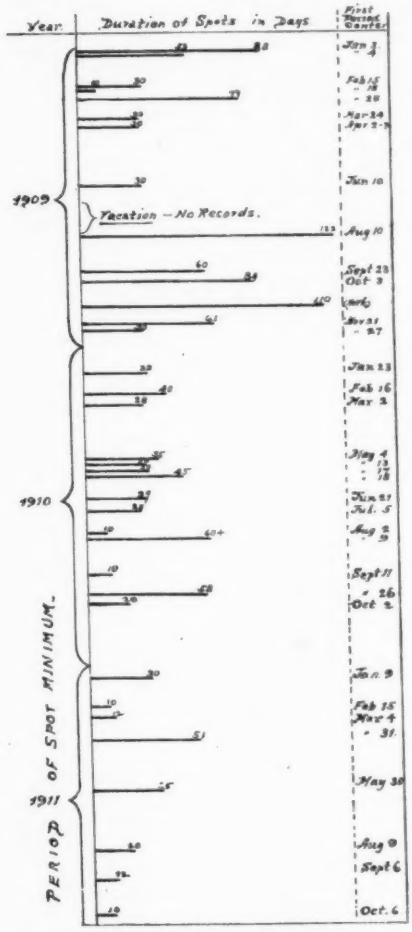
"When I consider the heavens
The work of thy fingers
The moon and the stars, which thou hast ordained;
What is man, that thou art mindful of him?
And the Son of man, that thou visitest him?
For thou hast made him but little lower than God
And crownest him with glory and honor."

ON THE NATURE AND ORIGIN OF SUNSPOTS.

W. F. CAROTHERS.

There are some lines of evidence bearing upon the nature and origin of sunspots which I have never seen advanced and I present them herewith. Insofar as my remarks are based upon personal observation they are limited to visual phenomena of the past three years. The first half of this period I used

a Bardou 2-⅝ inch telescope, while from April 1910 to date the observations have been made with my new and incomparable Clark six-inch refractor. During the year 1909 I recorded 80 observations of the sun on separate days; during 1910, 202 such observations and up to date this year 140.



PENUMBRAL SUNSPOTS—RELATIVE DURATION.

I refer especially to the hypothesis that sunspots are caused by down-pours of cooler vapors from upper strata of the solar atmosphere.

I suppose it is well established that these upper strata have shorter periods of rotation than has the photosphere. This seems to be due to the general contraction of the sun, the outer envelops bringing in with them their greater velocities. For instance: If the earth should be brought in to revolve around the photosphere, retaining her present orbital velocity, she would make the circuit in less than two days where the photosphere requires 26 days and upwards.

These considerations being true we should expect the spots to exhibit tendencies toward shorter periods than that of the photosphere if they are down-pours of vapor falling from more rapidly moving upper strata. Now observation shows that the principal spot in a group and the larger end of the familiar pearshaped spots take the lead, and, since it is here that we should look for the greater volumes of the descending matter,

here also we should expect to see the principal forward momentum reveal itself, and therefore observation sustains the hypothesis in this respect.

Again, groups and related spots approximate an east and west formation—as if strewn along from the more rapidly moving upper strata. It may be that this could be explained as a general effect of equatorial acceleration on other hypotheses and it is not so convincing as the other but it should not be overlooked.

Then too, the approximately round form of the spots accords with the theory under consideration. If we regard the photosphere as a fiery ocean of vapor, there would be a horizontal pressure against the invading downpours, which would be equal from all sides, thus giving the spots their generally round form. In such case the spots would persist in due proportion to the relative strength of the two forces, and, if the downpour should slacken, or if the ocean pressure should increase, the spot would be overcome and effaced.

In this connection I have considered by itself the probable effects of an increase of solar temperature. It would undoubtedly increase the upward pressure of the lower strata, above the photosphere thus tending to prevent the downpours and to lessen the number of spots, and, at the same time, I think it would increase the horizontal pressure of the photosphere before mentioned, thus tending to shorten the lives of such spots as might form. Following this idea I prepared a diagram of all of the penumbral spots which have appeared since I have been observing and of which I have any record, to see if there is such a relation between the duration and the number of sunspots, taking advantage of the fact that we have entered a period of spot minimum since my records began. The diagram accompanies this article. I selected only the penumbral spots on the supposition that they would furnish the best evidence. The identity of the various spots as they have rotated into and out of view has been established by the use of my tabulating solar discs described in P. A. for June 1910. The synodic longitude of spots has been determined by careful observations of their dates of passage over the limbs and center of the sun and I think my records are accurate in this respect to within 10 or 12 degrees of solar longitude. The lengths of the heavier horizontal lines show the relative longevity of the spots discussed shown also by numerals at the end of each line, including an estimate of their endurance before and after they

have been observed, even after the penumbra may have disappeared. The diagram is also scaled vertically so that the relative number of the spots at given periods may be seen. The date at the right hand of each spot line is the time of its first passage over the sun's center and is added for purposes of identification and comparison.

The result shows an apparent tendency to shorter lives for the spots as we have advanced into the present period of spot minimum.

Of course amateur observations for so short a period cannot be more than suggestive, but if an examination of adequate records should establish it as a fact that the duration of sunspots is relatively shorter during periods of spot minima, that fact would be highly significant, not only with reference to the nature and origin of sun spots, but with reference to the current problem of variation in the solar temperature, indicating that the temperature of the sun is greater during the spot minima. This, in turn, would solve the puzzling phenomena of the spot minima and maxima, demonstrating that they are due to periodic variations in the solar temperatures.

Houston, Texas,
October 9, 1911.

A MARCH EVENING AT THE LICK OBSERVATORY.

DR. EDWARD GRAY.

From Monday the 11th to Saturday 16th March it had been rainy in Central California, except only on the 14th, which was a fine day. Now it was Saturday, the 16, and the sky all beclouded with milky cirrus. But when a friend has journeyed 650 miles to meet you upon the one evening in the week when the Lick Observatory is open to the public, what are you going to do? According to arrangements made, by letter, beforehand Mr. E. L. Forsyth, of Needles, and I met that morning in San Francisco at the S. P. station bound for San José. We were to take the auto stage for Mt. Hamilton at 4:30 p.m. We did so, but with some misgiving for the outcome; for only the scud had cleared away while the extensive canopy of thin white, cirrus cloud was not lifted. The journey from San José to the observatory is 27 or 28 miles in length; and from the valley we could see some fresh snow near the summit of Mt.

Hamilton. Below this the hills and lower mountains were clothed in freshest green, recently washed, and fairly emerald in the chastened sunshine; for, as we proceeded, the sun gained strength and the layer of cloud melted away. On we went over the crooked mountain road, with buckeyes in fresh leaf, oaks just budding forth and wild flowers in blossom. My companion declared that the ride was worth the journey even if we should see nothing in the sky. At 7:15 we dismounted at the front door of the observatory, and lo! five inches of snow lay about us. By this time the sky was so clear that we were sure of good seeing. Just as we were announced Mr. Wright was busy taking a photograph of the spectrum of the Nova in Gemini; and we had to wait quite three quarters of an hour before being admitted to the 36-inch telescope. Meanwhile, after warming ourselves a bit at the stove in the visitors' room, we were conducted to the dome of the 12-inch telescope by Mr. Ralph Wilson, Assistant Editor of POPULAR ASTRONOMY. The first object in the celestial scenery which claimed our attention was Saturn, as being low in altitude. This we observed with two powers, a low and a medium. The "crape" ring was readily discernible, of a smoky brown color. About this time Dr. Aitken joined us. Mars being distant, was faint and very unimpressive. The next object was the Antalgol variable U Geminorum. It was faint but not quite at minimum. The telescope was now turned on the great nebula in Orion, the trapezium showing six stars. Then adjourning to the great dome, we saw the spectrograph dismounted and the visual cap replaced. Mr. Wright announced his plate of the Nova as satisfactory. Dr. Aitken now took charge and selected the great nebula in Orion to show to the assembled visitors. Through the great telescope this was a charming object, its different densities and cloudlike portions being plainly brought out. The trapezium now showed eight or ten component stars, according to one's interpretation. The illustration given in Dennings "Telescopic Work" as Fig. 63, p. 319, shows nine, one a double star.

On our way to the great dome we just missed seeing Canopus because some cloud or fog was still near the horizon in that part of the sky.

All the other visitors having been dismissed—they were all young fry—Dr. Aitken now proceeded to satisfy my request to see nebula 1532 in Gemini. After setting the circles a little

adjustment of the slow motions soon brought from him the exclamation: "Ah here it is" in a tone of much satisfaction. Yielding the seat to me he said: "It is a beautiful planetary nebula." It was so indeed. Surrounding a central star of about 8.5 magnitude are two concentric disks separated by a narrow dark ring. It is a unique object worth, as Mr. Forsyth said, coming a thousand miles to see. Wr. Wright was now present and Dr. Aitken called him to look at it.

This object is described by Webb and, better, by Serviss, in the "Pleasures of the telescope" at pp. 41, 42. It must be clearly understood, however, that the illustration there given is not a portrait but merely a diagram of the object. The dark ring is drawn far too broad; a hair line will represent it; while the nebula cannot be represented, with any propriety, by means of concentric rings, and the central star shines with a brightness which cannot be transferred to paper. No engraving can adequately convey the softness of the nebula and yet its perfect visibility.

And now with genuine thanks to Dr. Aitken for his courtesy, we too withdrew to permit the astronomers to go on with their work; for clear nights had been a rarity this month even at the Lick Observatory.

After viewing several stands of transparencies of comets, nebula and such like and some desultory conversation Mr. Wright accompanied us to the front door and from the steps pointed out to us the Nova in Gemini.

It had been of the fourth magnitude, or equal to Theta the week before, but was now at 6.5, the limit of naked eye visibility at Mt. Hamilton. This concluded our sight-seeing and we were soon whirling down the mountain side to our destination in the valley with a lively sense of our privileges on this visit to the great Lick Observatory and with a keener appreciation of the apostrophe of the Psalmist: "When I consider the heavens, the work of thy fingers, the moon and the stars which thou hast ordained; What is man that thou art mindful of him?" Truly an undevout astronomer is mad.

Eldridge, California.

THE FORM OF THE EARTH.

WILLIAM THAYER JORDAN.

It would seem to be rather pretentious to attempt the treating of such a subject as the shape of the earth in an article like this: and indeed it would be, if it pretended to be a full and technical discussion; but there are certain simple and fundamental principles which we can easily study, and to these we shall confine ourselves.

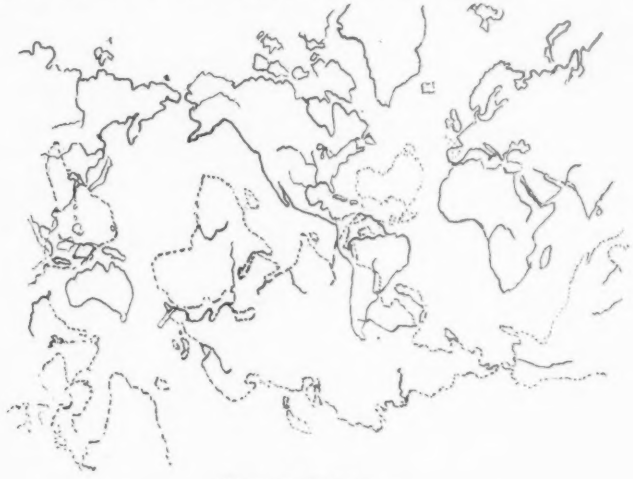
We are familiar with the general terms in which we describe the earth as a flattened spheroid, the probable warping of the ocean surfaces from the perfect spheroid, the sunken ocean-basins, and the uplifted continental masses; but the relation of the ocean-basins and the continental masses to each other and their arrangement relative to the earth's axis of rotation, and the law governing the general trend of the mountain ranges, or, as they have been well called, "World-ridges", which extend across both the ocean basins and the continental masses, we are not so familiar with, and they may well repay our further study.

We will first consider the relations between the ocean-basins and the continental masses. If we turn to the accompanying map, it shows us at once that the most striking and obvious relation is that the ocean-basins and the continents lie opposite each other on the globe.

We see that North America is directly opposite the Indian Ocean; Africa, Europe, and the by far larger part of Asia lies opposite the South Pacific, the Antarctic, and South Atlantic Oceans; that Australia is opposite the North Atlantic; and that the continental mass around the south pole is opposite the North Polar ocean; and that Greenland is opposite the Antarctic ocean. The only exception being that perhaps less than a third of South America is opposite a corresponding area of Southeastern Asia—a very small exception considering its area relative to all continental masses. And, as every one knows, the Northern is the land hemisphere, and the southern the water hemisphere.

When all these facts are considered, it is impossible to think all this a mere chance arrangement; and we are compelled to conclude that the sinking of the ocean-basins and the rising of

the continental masses on the opposite side of the globe are related to each other as cause and effect; the sinking of heavier masses underlying the ocean beds causing the rising of the continents on the opposite side by the corresponding change of the earth's center of gravity, and also by the push of the sinking masses. And the sinking of all the ocean-basins and the rising of all the continental masses go on at the same time (are still in progress); for from the very earliest geological ages there is little or no evidence that the ocean beds and continental areas have ever been fundamentally changed; thus showing the continuous action of the same cosmic forces. Some geologists consider the ocean deeps as the oldest and stablest element of the whole terrestrial surface.



MAP OF WORLD.
Dotted lines showing opposite side of the globe.

This sinking of the ocean beds and a corresponding rising of the continents would continue until they balanced each other; and then would come a period of comparative rest, with the slow wearing down of the continents by erosion, and with this a corresponding accumulation of the eroded material upon the continental shelves which border all the continents and lie beyond the shore line. Added to this often great deposits of carbonate of lime accumulate upon the continental shelf and at the bottom of shallow seas. But with this changing of material from continents to ocean beds there would arise a slowly accumulating push and stress from the ever growing

heavier mass transferred to the ocean-basins and the ever lessening weight of the continents until, when the difference in weight had become great enough, the force of gravity would overcome the resistance of the vast masses involved, and then there would begin another sinking of the ocean-basins and corresponding rising of the continental masses, continuing until these masses and forces had again adjusted themselves. And this stress and movement would probably give rise to a period of volcanic activity to be followed by a period of decline and of comparative repose. Thus would arise those world wide periodic movements, recurring at long intervals, that seem to have marked the passing of the great geologic eras. Of course, this would not exclude faster or slower movements at other times, or varied independent movements as the rising or falling, wrinkling and folding of the separate continental masses or smaller sections of continents or ocean beds from other causes, as the contraction and resulting thrust of their crust; for after being once uppushed each continent would act in many ways as a unit by itself; as is suggested by many twistings in some of the mountain ranges.

We have referred to the effect of the contraction of the crust; but mathematical physicists have calculated the possible uplift that could be produced by any probable rates of contraction, and have declared them too small to account for the existing elevation of the land.

As a whole the ocean-basins would be steadily growing deeper; but the continental areas would be constantly worn down by erosion. Relatively the ocean basins have now sunk about one mile and the continental areas have been raised about two miles.

These periodic movements of the continental masses would by the change of altitude, the relative position of land, sea and mountain ranges greatly modify the climate; and thus at such times occasion rapid changes of the flora and fauna; and by thus effecting great changes in environment be a large factor in producing for the time a markedly rapid evolution of new forms.

We would especially call attention to this periodic elevation of the continental masses as the probable explanation of the so-called Ice Ages, or glacial epochs. Every where, as our mountain ranges show, any great elevation of any considerable land mass results in an increased precipitation of moisture; and if the elevation is high enough, this precipitation is in the form of snow. And if of still greater altitude, the snow will fall

faster than it will melt, and in time accumulate until it begins to slowly flow down the natural inclines, thus forming glaciers. The territory covered by these glaciers depends, of course, in the main on the size of the uplifted area, some being small as in the Alps; but others large, as in Greenland or in the region around the South Pole.

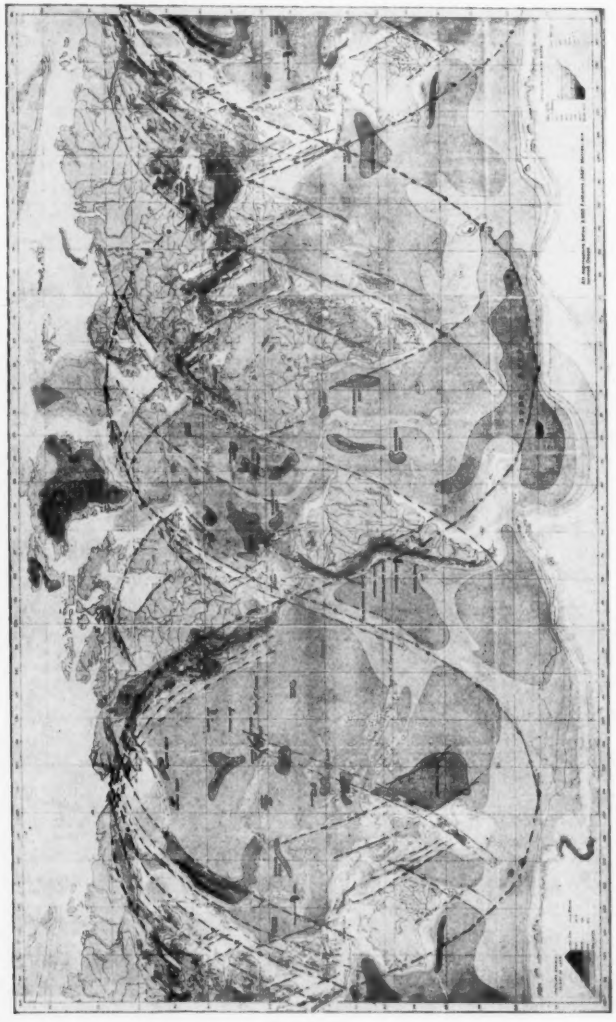
It is not easy to realize how small the uplift would have to be in proportion to the diameter of the earth to raise the continental masses above the snow line, even at the equator; and, of course, growing ever less as the poles are approached. And, too, the larger the area thus elevated, the less the rise would have to be to cover it with glaciers. The existence today of ancient river valleys and channels along the Atlantic shore line, such as that of the Hudson, that extend far out under the sea, are evidence of a past elevation of the east coast, perhaps sufficient, if large portions of the interior were correspondingly raised, to produce the glaciers of an Ice Age over a large portion of the continent. And perhaps the elevation of the region from which the glaciers flowed was at that time very much more considerable. That such great changes of elevation have occurred repeatedly in the past ages is one of the commonplaces of geology.

We used to talk of an Ice Age, and then of Ice Ages, that covered vast areas, and we tried to explain them by changes in the eccentricity of the Earth's orbit, combined with the progresion of the place of the winter solstice, causing long winters and short summers for one hemisphere, and then the other.

Others tried to explain the existence of glaciers over regions now possessing a warm climate by a supposed movement of the poles; but we have no evidence that the poles have ever varied more than a few feet from where they now are. And we shall see later how the arrangement of the shore lines and mountain ranges shows that the earth's axis has remained unchanged through all the geologic ages.

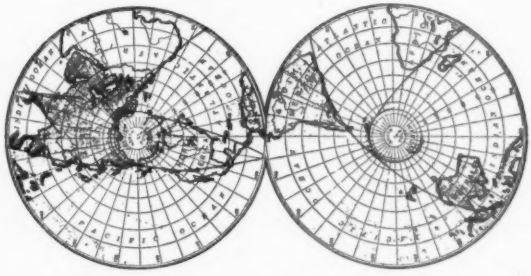
If the reader will consult any map showing the direction of the flow of the great world glacial masses it will make plain two things. The first is that the ice moved in every direction, north as well as south from the elevated regions, wherever situated; and second that northern Siberia, the coldest region in the world, never was glaciated, as far as any present knowledge goes.

And so we are led to conclude that however long the time and large the area covered by the glaciers they were caused by an elevation of the ice covered area, and that they were the result of the periodic movements of the continental masses. Geology, and not astronomy, furnishes the explanation of the of the glacial epochs.



BATHYMETRICAL CHART OF THE OCEANS
Showing the "Deeps" according to Sir John Murray. Dotted lines showing great circles tangent to the Polar Circle.

We will now consider the arrangement of the ocean-basins and their resultant continental masses relative to each other and to the earth's axis of rotation. A study of the accompanying bathymetrical chart will show us that this arrangement is not a thing of chance; and that the lines that mark the continental edges, as a rule, approximate a well defined law relative to the axis of revolution. And with these we must consider another marked world characteristic, and that is, the general trend of the world-ridges, or mountain ranges. It was long ago pointed out by Dana that the greatest mountain ranges stand opposite the greatest ocean beds and along the borders of the continents. It would necessarily seem that between the main continental masses and the neighboring sinking ocean-basins there would be a region of great stress, and here we find the crust folded into gigantic wrinkles forming these mountain ranges. But beside these coastal ranges we have other wrinkles, or ranges, far from the shore, some crossing the continents, and some the ocean-basins. And we need to remember that wrinkles or waves mean and include depressions as well as crests.



A study of the chart, observing that the dotted lines are the projections of great-circles tangent to the Polar Circles, will show us that the shore lines of the continents, the continental shelf, and the concavities that lie beyond them, and the great world-ridges and valleys, whether continental or submarine, all follow approximately the same law, and that is:

The Great Shore Lines and the Great World-ridges and hollows are nearly All approximately along great circles tangent to the Polar Circles.

This law, according to Dana, was discovered as long ago as 1857 by Professor R. Owen of Indiana; but seems to have been generally forgotten by later writers.

Now this law is so clearly evident as to leave no doubt as to its being due to some general cause or causes, and the following is an attempt to find what the causes may be.

To show the well nigh universality of this law we will call attention to some of the more marked cases; and many minor ones can be quickly seen by a brief study of the chart.

Beginning at the left, we see that the eastern shore of Asia from the lower point of the Malay Peninsula to the terminal of East Cape in Bering Strait is approximately along the line of a great circle, tangent to the Arctic Circle at about 160° west longitude. So also are the shore lines of Kamchatka and all the long line of islands that stretch from Cape Lopatka off the eastern shore of Asia to the western end of Borneo. This great circle being, of course, tangent to the Polar Circle at a point further east than the one first mentioned. A part of the eastern shore of Australia follows a tangential circle. And nearly all the edge of its eastern continental shelf. And very markedly the eastern and western shores of New Zealand and the line of islands and ocean-deeps that lie to the north follow yet another such circle. And let us note, for we shall have occasion later to refer to it, that the line that approximates the south-west coast of the Malay peninsula and the west coast of Australia is tangent to the Antarctic Circle at about 180°.

Before passing eastward let us observe that many, just as marked, but shorter, shore, mountain and island lines in Oceanica follow the curve of opposite tangential great-circles.

But moving easterly we find that the American shores with their accompanying mountain ranges closely approximate great circles tangent to the Arctic Circles at about the same longitude as those which mark the eastern coasts of Asia. In fact they are approximately the same circles. And this holds true of the shore lines until we reach about the 20° of south latitude on the South American coast; but from there south to the Strait of Magellan we have one of the few exceptions to this law, as it also is of the first mentioned law, that the continental masses lie opposite the ocean-basins.

Returning to North America we have the northern shores of Hudson Bay and the Labrador coast approximately all on the same tangent; and the southern shore of Hudson Bay following another tangent.

Coming to the eastern coast, we find that this, too, follows a tangent, but one curving the same way as the eastern Asiatic

coast. This world-ridge is of peculiar interest, tangent to the Polar Circle at about 0° longitude, one of the most important of tangential points of great-circles determining the great world-ridges, and to be more fully noted later. It passes through Iceland, the southern point of Greenland, the strait of Belle Isle, crosses the Gulf of St. Lawrence; and following the Atlantic shore line is shown in the Appalachian ranges, the coast line, and the continental shelf. (The Florida Peninsula following tangent lines parallel to the Pacific coast.) Continuing south this great world-ridge again shows itself in the mountain ranges and shore lines of Yucatan, and the Mosquito Coast, and then crossing to the Pacific reveals itself in the long sub-marine ridge shown on the chart, and which rises above the sea level in the Galapagos, Sala-y-Gomez and Easter Islands. The North-western coast of South America from Cape Gallinas in the Carribean sea south-westerly to Cape Blanco in the Pacific is also along such tangential lines, but further to the east.

Map showing points of tangency of some of the more important coast lines to the N. polar circle

Map showing points of tangency of some of the more important coast lines to the S. polar circle

Passing many minor, but yet interesting lines, we come to another of the great world-ridges, one that is tangent to the north Polar Circle at about 50° E. longitude and follows the trend of the south shores of the Baltic and North Sea, the Atlantic coast of Europe, northern Africa, and the east coast of South America from Cape St. Roque to the extreme end of the continent.

We here again will briefly note some of the shorter ridges and depressions that follow tangential lines, as the general trend of theeast coast of th British Islands, the Mediterranean

coast of Spain from Cape De Gata to Cape Creau, the coasts of Italy and the Apennine range, the Adriatic Sea; which latter line produced is approximately the tangential line determining the depression of the Red Sea with its bordering shores and mountain ranges and parts of the easterly coast of Africa. Beside these there are many other lines which the chart plainly shows.

Photograph of relief globe.

Map showing important coast lines.

The next great tangential world-ridge, as we pass easterly, is very interesting in that it determines the eastern shore of Africa and its coastal ranges, the northwestern shore of the Arabian Sea; and yet further north develops into great mountain ranges, and becoming as it meets the Himalayas the, "Roof of the World," and still further north the Thain and Altai ranges, and at last finally dying out in northern Siberia as it approaches the Arctic Circle. The accompanying picture from a relief globe shows this interesting world-ridge as no words or chart can. And if the reader has a globe so mounted that it can be set with a great-circle tangent to the Polar Circles, then as it is revolved the approximation of the great coast lines, mountain ranges and allied phenomena to the tangent circles will be still more strikingly seen.

We would also call attention to the shore lines and coastal ranges of India, which, as the chart shows, are determined by opposite tangential lines intersecting near its southern extremity. The shore lines of Burmah, the shore lines and coastal ranges of Siam, the Malay Peninsula, the Island of Sumatra, and the western shores and mountain ranges of Australia are all on the same tangential world-ridges. And here it were well

to note that those lines are approximately tangent to the North Arctic Circle near 0°, and of course to the South Polar at about 180°, important tangential points to be more fully considered later.

Returning to the great world-ridges, let us consider once more the tangential ridge that determines the eastern coast of Asia to further note that it seems to determine the course of the great submarine ridge, shown on the chart, from which rise the Amsterdam, St. Paul, Kerguelen, and Macdonald Islands; and then, yet further south after leaving this ridge it follows the edge of the great Ross deep until this tangent touches the South Polar Circle approximately at 0°, another of the important tangential points.

Some of the depressions are well worth noticing as conforming to the same law, as Lake Baikal, the trend of the Yukon river from the Polar Circle to the sea, Great Slave Lake, and the Fish river.

It was long ago pointed out that as a rule the more part of the volcanos lie along the coast lines; but it is also true that they are largely along great tangent lines whether coast lines or no, as the long line of island volcanoes of the Pacific, the Antilles, and the mid-continental extinct or slumbering volcanoes of the Rocky Mountains in America. And perhaps it were well here to note that the most active volcanic regions of the world are approximately where great tangential world-ridge circles intersect, as the Mexican, Carribean, Java-Philippian, and Mexican-West Indian; and that they are approximately opposite each other at the intersection of the great world-ridge tangents.

We will now inquire more fully for the causes and processes which brought about this arrangement of the earth's surface which we have been noting; and we shall find them to be surprisingly simple in their general terms; but as in all realms, infinitely complex in ultimate details.

To account for the relation of the seas and the continental areas, the world-ridges and deeps, and the law of their arrangement relative to each other and to the earth's axis of revolution, which we have above observed, we need but to premise the following, namely, that the earth is a cooling mass of heterogeneous materials of varying densities, the force we call gravitation, and the centrifugal force caused by the earth's revolution.

Now if the earth be a heterogeneous mass of varying densities, then the heaviest materials would, of course, under the gravitational force find their way to the center; and the lighter materials be arranged in order of weight from center to surface. But while this would be the ultimate arrangement where all the particles were free to arrange themselves according to their density, it would not be the case, or would be but slowly approached where a heterogeneous mass was thrown together, as is now claimed to be the case by the latest theories of the origin of the earth.

We shall need to go back to the later modification of the nebular hypothesis, the planetesimal hypothesis, for our starting point. This hypothesis requires that the nebular material shall be composed of not only gases but also of solid masses from the size of perhaps some of the asteroids down through the meteorites, to cosmic dust and gas molecules. And these solid masses to be of varying degrees of density and of specific gravity. We find this great variety in the meteorites, as some are stone, and others iron and nickle. The ratio of the specific gravities of the stone to those of the metallic meteorites is about three to seven or eight.

Now if our earth was formed from the gathering together of such scattered bodies of such greatly varying material about the largest member of that part of the nebula which was ultimately to constitute the earth, we would have at hand the mass of heterogeneous material of varying densities which we need to explain the present form of the ocean basins and continental areas and the trend of the great world-ridges. For all we need is to suppose that toward the close of the ingathering some of the heavier masses so fell upon the growing planet that their arrangement relative to the surface correspond roughly to the deeper portions of the ocean-basins of today; so that "Deeps" or anti-plateaus are where the heaviest of the latter infalls took place.

It has been long known that the center of gravity of the earth is not the center of the figure of the globe; but lies south of it, in the hemisphere of the larger ocean-basins. And must have been so from the earliest ages; for it is impossible to conceive of any large rearrangement of the earth's interior subsequent to the final infalls whatever their source.

To be Continued.

THE PROPER MOTION OF TWO MARKINGS ON JUPITER.

LATIMER J. WILSON.

Frequent observations of Jupiter with a telescope of sufficient aperture will disclose the fact that constant and rapid changes are taking place upon the disk of the planet. Occasionally there are certain markings which remain long enough to afford an opportunity for interesting inquiry into the forces which actuate their movements. It is the purpose of this paper to present a few of these observations rather than to attempt to explain them. Jupiter was carefully observed during the apparitions of 1910 to 1911, the observations mentioned here were made in May, June, July and August of 1911. The telescopes were Newtonian reflectors of ten and eleven inches aperture, the ten inch being used only in May and June. The magnifications ranged from three hundred to four hundred and twenty five. The usual power was about three hundred and fifty diameters.

On May 17th, when seeing conditions were almost perfect, a conspicuous dark spot was seen in the southern component of the south equatorial belt in longitude 108°, and latitude —15°. It was elliptical, the major axis measuring about two seconds. The spot was so dark that it could easily have been mistaken for a shadow of a satellite had it been seen in the latitudes traversed by the shadows when in transit across the disk of the planet. The aspect of the spot suggested a hole in the belt, and since the prevailing opinion is that the dark belts of Jupiter are crevices or wide gaps in the shell of cloud which forms the visible surface of the planet, this dark spot, if a hole, was evidently very deep. Observations of Jupiter had been made regularly since March. The place occupied by the spot had been observed on May 16th and, as there was no indication of anything unusual, it is likely that the dark spot formed during the interval of twentyone hours preceding the observation of May 17th. Two observations of this spot, confirming its reality, were made in England on June 2nd. (English Mechanic No.2413-510, No.2416-587). On the evening of May 17th another marking was seen here for the first time. It was an intensely white spot, so brilliant that it was projected against the white background in south latitude 27°, south of the disturbance known as the South Tropical Dark

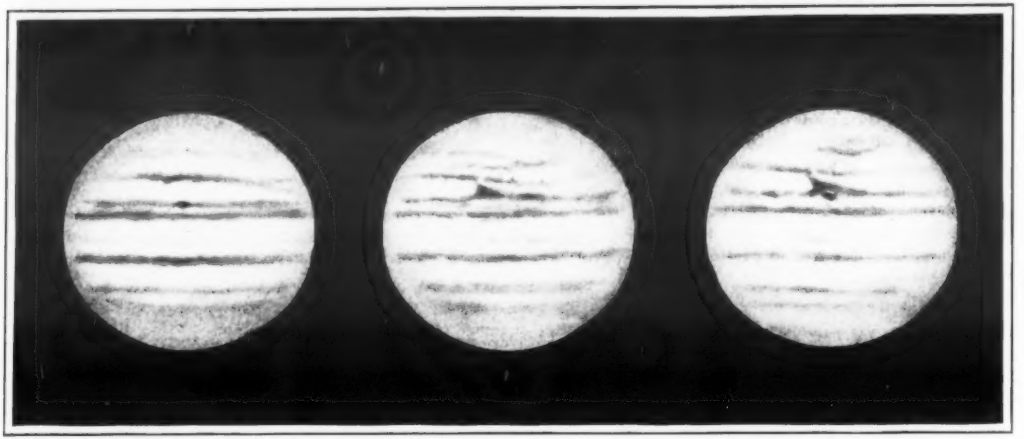
Area. Its longitude was then 178°. Subsequent observations showed what seemed to be a variation in the light of this spot, an effect which could not have been entirely due to the atmosphere, because at times when the seeing was bad the spot was almost conspicuous.

Aside from a peculiar change in the direction of the major axis of the dark spot and the variable character of the white spot, the chief interest in these markings was in their irregular proper motion, the longitude of the dark spot increasing while that of the white spot decreased. From May 17th to August 2nd, the longitude of the dark marking changed from 108° to 141°, and that of the white spot passed from 178° to 110°. The accompanying table gives the observations, to which should be added an observation of the dark spot on June 3rd, 14h 46m, G. M. T. The table also gives the transit of the 0° meridian, the rotation period, and the hourly motion of the meridians of system II. Reference to the table will show that during the interval from May 17th to the 29th the dark spot moved in longitude at the mean rate of a little more than one degree a day. Then the mean motion was retarded until July 14th, being less than 0.3° a day. From the 14th to the 16th it was about 1° a day. From July 16th to the 19th the marking seemed to pause, the longitude actually decreasing about one degree daily.

It is interesting to note that the white spot was also retarded at the same time. The latter apparently had a general motion contrary to that of the dark marking, its drift being in the direction of the planet's rotation. Considering this fact as well as the aspect of the phenomenon it would be natural to infer that the white spot was connected with the upper regions of Jupiter's cloud covering. White spots in general seem to have a direct motion more rapid than the system to which they belong. For seven days after its discovery there was apparently no change in longitude of the white spot. Reference to the table will show that its motion began in the interval between the 24th and the 29th of May, the daily motion being more than 1°. From the 29th to June 3rd the motion was ½° a day, from the 3rd to the 10th it was about 0.8°, from the 10th to the 13th it was 0.7°, from the 13th to the 7th of July it was more than ½° daily, and from the 7th to the 9th it was about 1°. From the 9th to the 14th it was 2° and then the motion seems to have been arrested during the interval from

PLATE XI.

S



MAY 17. 1911
G. M. T. $15^h\ 24^m$

MAY 24
$18^h\ 5^m$

JULY 19
$13^h\ 17^m$

JUPITER SHOWING THE DARK SPOT, THE SOUTH TROPICAL DARK AREA AND THE BRILLIANT WHITE SPOT, AND THE TWO SPOTS NEAR CONJUNCTION.

the 14th to the 16th, after which it again decreased in longitude, travelling in the direction of the rotation of the planet. From the 19th to the 26th the rate was 0.7°, and from the 26th to August 31st the mean motion was 0.6°. When the observations are freed from probable errors the refined results may alter these figures somewhat, but the fact that the spots were moving in contrary directions, and that they were influenced by the same underlying cause will remain apparent. An effort was made to study the dark spot in detail; and during the intervals of best seeing its general appearance strongly suggested the umbra and penumbra of a sunspot. No detail could be seen in the penumbral border of the marking, but at times slanting wisps seemed to connect the spot with the northern component of the south equatorial belt. As the preceding shoulder of the South Tropical Dark Area was approached, the dark spot, on July 7th, seemed to project into the white space between the two components of the south equatorial belt. Referring to the proper motion of the spot its preceding part was tilted northward. When the shoulder of the Dark Area was reached the preceding part of the spot was tilted southward. During the interval of its passage along the northern border of the South Tropical disturbance the motion of the elliptical spot was wave-like, first the forward part would be tilted downward and in a few days it would have an opposite tilt. Efforts were made to determine whether or not the marking actually turned completely around, but the observations were interrupted. It is interesting to mention that on the night of July 9th another dark spot had formed at about the same distance ahead of the South Tropical Area where the spot of May 17th was first seen, but within a few days it had disappeared. The South Tropical disturbance had a decided direct motion as can be seen by the following:

TRANSIT OF THE PRECEDING SHOULDER OF THE S.T.D.A.

April 21, 1911.	15h 40.00m	Transit of 0° = 11h	1.77m G.M.T.	λ 168°
July 14,	14 8.00	"	10 20.55	λ 137°

TRANSIT OF THE CENTER OF THE S.T.D.A.

April 21,	16h 15.00m	Transit of 0° = 11h	1.77m G.M.T.	λ 189°
June 10	17 2.00	"	12 11.73	λ 175°

These give a direct mean motion of .36° for the preceding part of the marking and .27° for the center, daily decrease in longitude.

TRANSITS OF A DARK SPOT IN —15° LATITUDE. SYSTEM II.

Date	Observed tr. G.M.T.		Transit of 0°		Rotation Period		Hourly Motion	Longitude	Seeing
	h	m	h	m	h	m	°	°	
May 17	15	24.00	12	24.30	9	55.62	36.26	108	1±
29	15	38.00	12	17.60	9	55.64	36.26	121	2±
31	17	22.00	13	55.84	9	55.65	36.26	124	2±
July 6	17	21.00	13	41.34	9	55.73	36.25	132	3±
9	14	54.00	11	11.53	9	55.74	36.25	134	3±
14	14	8.00	10	20.55	9	55.75	36.25	137	4±
16	15	50.00	11	59.35	9	55.76	36.25	139	5±
19	13	17.00	9	30.71	9	55.76	36.25	136	3±
26	14	8.00	10	17.82	9	55.78	36.25	139	3±
Aug. 2	15	00.00	11	6.15	9	55.79	36.25	141	4±

TRANSITS OF A WHITE SPOT IN —27° LATITUDE. SYSTEM II.

Date	Observed tr. G.M.T.		Transit of 0°		Rotation Period		Hourly Motion	Longitude	Seeing
	h	m	h	m	h	m	°	°	
May 17	17	19.00	12	24.30	9	55.62	36.26	178	1±
24	18	5.00	13	9.92	9	55.63	36.26	178	1±
29	17	5.00	12	17.60	9	55.64	36.26	173	2±
June 3	16	8.00	11	25.38	9	55.65	36.26	170	2±
10	16	45.00	12	11.73	9	55.66	36.26	165	2±
13	14	11.00	9	41.49	9	55.67	36.26	163	2±
15	15	48.00	11	19.92	9	55.68	36.26	162	2±
July 7	13	37.00	9	32.80	9	55.73	36.25	147	3±
9	15	12.00	11	11.53	9	55.74	36.25	145	3±
14	14	10.00	10	20.55	9	55.75	36.25	138	4±
16	15	52.00	11	59.35	9	55.76	36.25	140	5±
19	13	21.00	9	29.70	9	55.76	36.25	139	3±
26	14	1.00	10	17.82	9	55.78	36.25	134	3±
Aug. 31	13	15.00	10	12.66	9	55.82	36.25	110	3±

Scale of seeing 1 = best, 5 = limit at which detail could be seen.

OBSERVATIONS OF NOVA (2) GEMINORUM.

FREDERICK C. LEONARD.

The new star discovered in the constellation Gemini on 1912 March 12, by M. Enebo at Dombaas, Norway has been observed by the writer on every clear night since March 15, when the news of its appearance was first received here. All of the observations of this nova have been made with a 3-inch equatorial refractor, and in substance are as follows:

OBSERVATIONS OF NOVA (2) GEMINORUM

1912 March 15—April 11.

Date	h	m	Mag.	Comparison stars	Color
Mar. 15	7	0*	4.1	θ and ρ Geminorum	Very Pale Yellow
" 16	8	0*	5.1	ρ and ϕ Geminorum	" " "
" 17	7	30	5.3	ϕ Geminorum	" " "
" 18	7	45*	5.4	ϕ Geminorum	" " "
" 19	7	30	5.5	ϕ Geminorum	Very Slightly Pinkish
" 21	7	35	5.6	ϕ Geminorum	Strongly Light Pink
" 22	7	25	5.6	ϕ Geminorum	Light Pink
" 24	7	30*	4.8	ϕ Geminorum	Creamy White
" 27	7	30	5.9	ϕ Geminorum	Light Red
" 29	8	30	5.8	ϕ Geminorum	Fiery Red
" 30	7	30	5.8	ϕ Geminorum	Light Red
Apr. 2	7	40*	5.7	ϕ Geminorum	Decidedly Light Red
" 3	7	30	5.9	ϕ Geminorum	Copperish Red
" 4	8	10	6.1	B.D.+32° 1414 and 1433	Light Red
" 5	7	35	6.2	B.D.+32° 1414 and 1433	Red
" 7	7	55	6.4	B.D.+32° 1414 and 1433	Very Red
" 8	7	50	6.5	B.D.+32° 1414 and 1433	Deep Red
" 10	7	35	6.6	B.D.+32° 1414 and 1433	Rather Deep Red
" 11	7	40	6.7	B.D.+32° 1414 and 1433	Decidedly Deep Red

The times of all of the above observations are given in C.S.T. The magnitudes of the first three comparison stars, (namely, θ, ρ and ϕ Geminorum), which are "Standard Stars" of *N. A.* 1912, are in order:

θ Geminorum, mag. 3.6
ρ Geminorum, mag. 4.2
ϕ Geminorum, mag. 5.0

The magnitudes and positions, (1855.0), of the last two stars, (the B.D. stars), are respectively:

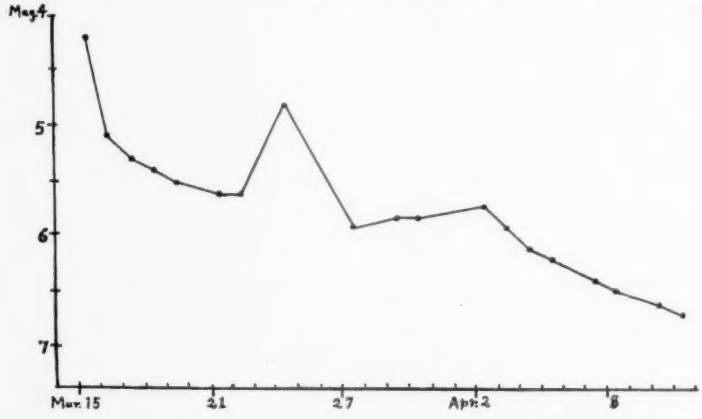
B.D. + 32° 1414, mag. 5.8, α 6^h 40^m $14^s.3$
δ + 32° 45′.6
B.D. + 32° 1433, mag. 7.0, α 6^h 44^m $41^s.3$
δ + 32° 41′.3

All observations marked by an asterisk (*) indicate that on those evenings in question the nova was visible to the naked eye.

It will be seen that the purpose of my observations of the new star have been not only to record its magnitude on the various dates it has been observed, but also to keep a complete history of its color changes, as well as of its alterations in magnitude. This I consider quite as much of value as its record of magnitudes and resulting light curve, for some of the changes of color it has passed through in relation with its variations in magnitude have been altogether remarkable. It will, in fact, be noted from the foregoing summary of observations of the star that the shifts in color have regularly accompanied the fluctuations

in magnitude. When the Nova has been at its brightest, (March 15, 16, 17 and 24), the color has been at its *lightest*, and as the magnitude has declined the color has deepened proportionally. In short, the color, in less than one month's time, has passed from a pure creamy white finally into a deep red, while the light, first to last, has declined two and one half stellar magnitudes. Hence, I deem it not inappropriate here to offer a suggestion that these peculiarly relative shifts in light and color may possibly furnish a key to the actual physical mutations and activities that have been in progress within the star itself.

Discussing the observations represented in the accompanying table, we find that on March 15 the Nova was of mag. 4.2 and very pale yellow, (creamy white), in color. From that date it gradually waned at the rate of about 0.1 mag. in 24^h until March 24. On the 19th it first began to change color from the very pale yellow to a delicate pink hue, and on the succeeding clear nights, (until the 24th), gradually deepened somewhat in color as it declined in magnitude. Then, all at once, on March 24, the Nova was found to be of mag. 4.8, or 0.8 as luminous as on the last observation, and the color was once more creamy white like it had been at first when the star was so bright.



LIGHT CURVE OF NOVA (2) GEMINORUM, 1912 March 15–April 11.

Then from March 24th it gradually dwindled, (not to mention a few slight increases in magnitude after this date), and the color slowly became more intensified from a light red, (on March 27), to a decidedly deep red on April 11, (the latest

observation). Therefore, the changes in light and color have corroborated each other all through the present history of this new star. Since April 4, the Nova has diminished in brightness at the rate of approximately 0.1 mag. in 24^h, and the hue has gradually deepened accordingly.

Above is given the light curve of the Nova drawn from the list of magnitudes presented in the preceding table. This will, graphically, and perhaps as well as any description, convey to the reader the variations in magnitude that have gone on in the star during the period of the foregoing twenty-eight days.

1338 Madison Park, Chicago, Ill.
1912 April 12.

PLANET NOTES FOR JUNE, 1912.

C. H. GINGRICH.

The sun will reach its greatest northern declination on Friday June 21, and will then be at what is known as the summer solstice. The sun will immediately again move southward and by the end of the month will have moved about a quarter of a degree south of its farthest point north. This will be the season of longest days. At the end of the month the earth will be near its aphelion, or the point of greatest distance from the sun.

The phases of the moon for this month are as follows.

Last Quarter	June 7	at	9 P. M.	C. S. T.
New Moon	15	"	1 A. M.	"
First Quarter	21	"	3 P. M.	"
Full Moon	28	"	7 A. M.	"

Mercury will probably be lost in the rays of the sun during the entire month. It will pass the sun on the side opposite the earth on June 16. It will be moving eastward much more rapidly than the sun and may possibly appear in the west just after sunset at the close of the month.

Venus will rise only a little while before the sun and will not be visible at all. It will be moving northward and will cross the plane of the ecliptic on June 18.

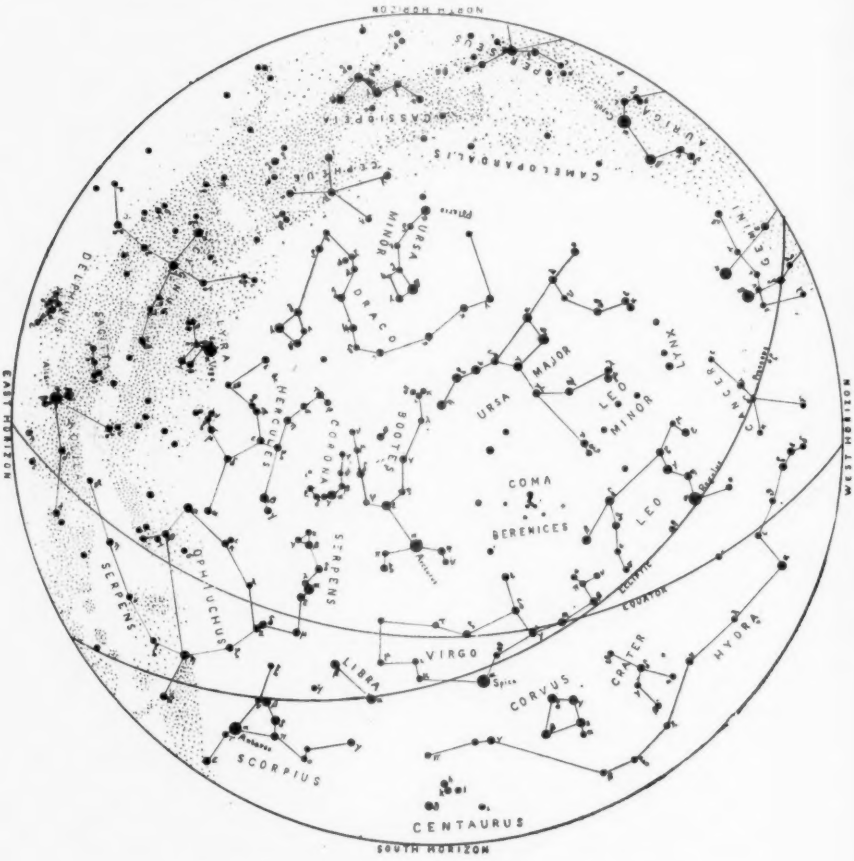
Mars will be rather low in the west at sunset during this month. It will be in the constellation Cancer not very far from the Praesepe cluster. It will be at the beginning of the month nearly in the line joining Castor and Pollux, the twins. Mars will reach its aphelion point on June 8.

Jupiter will be very well situated for observations during the month. It will rise shortly before sunset. It will be rather far south having a southern declination of 21°. It continues to have an apparent motion westward. It will be very near the star Antares, the brightest star in Scorpio.

Saturn will have passed the sun but will still be quite near to it at the beginning of the month. At the close however, it will appear again as the morning star.

Uranus will rise in the southeast shortly after sunset. It is in the constellation Copernicus.

Neptune will be low in the west at sunset. It will be nearly in the line joining Procyon and Pollux, much nearer the latter.



THE CONSTELLATIONS AT 9:00 P. M. JUNE 1, 1912.

Occultations visible at Washington.

Date 1912	Star's Name	Magnitude.	IMMERSION. Washington M.T. h m	IMMERSION. Angle from N. °	EMERSION. Washington M.T. h m	EMERSION. Angle from N °	Duration h m
June 25	42 Libræ	5.0	13 55	156	14 34	226	0 39
26	α Scorpii	1.2	11 08	70	12 22	316	1 14
26	116 B Scorpii	6.2	12 28	72	13 41	303	1 13
28	C.D.—28°,14268	6.4	6 42	117	7 48	226	1 06

Phenomena of Jupiter's Satellites.

Central Standard Time.

1912	h	m					h	m			
June 1	10	35	I	Tr.	In.	June 14	14	56	II	Sh.	Eg.
	10	35	I	Sh.	In.	15	14	03	I	Tr.	In.
	12	47	I	Tr.	Eg.		14	24	I	Sh.	In.
	12	49	I	Sh.	Eg.	16	9	14	II	Ec.	Re.
2	7	52	I	Oc.	Dis.		11	20	II	Oc.	Dis.
	10	06	I	Ec.	Re.		13	54	I	Ec.	Re.
3	7	13	I	Tr.	Eg.	17	8	29	I	Tr.	In.
	7	18	I	Sh.	Eg.		8	53	I	Sh.	In.
	8	31	III	Oc.	Dis.		10	42	I	Tr.	Eg.
	10	44	III	Ec.	Re.		11	07	I	Sh.	Eg.
5	14	27	II	Oc.	Dis.	18	8	23	I	Ec.	Re.
	17	19	II	Ec.	Re.	21	8	38	III	Sh.	Eg.
7	9	23	II	Tr.	In.		13	52	II	Tr.	In'
	9	42	II	Sh.	In.		14	50	II	Sh.	In.
	12	01	II	Tr.	Eg.	23	8	09	II	Oc.	Dis.
	12	22	II	Sh.	Eg.		11	51	II	Ec.	Re.
8	12	19	I	Tr.	In.		13	05	I	Oc.	Dis.
	12	30	I	Sh.	In.	24	10	15	I	Tr.	In.
	14	32	I	Tr.	Eg.		10	48	I	Sh.	In.
	14	43	I	Sh.	Eg.		12	28	I	Tr.	Eg.
9	9	36	I	Oc.	Dis.		13	02	I	Sh.	Eg.
	12	00	I	Ec.	Re.	25	7	31	I	Oc.	Dis.
10	8	58	I	Tr.	Eg.		10	17	I	Ec.	Re.
	9	12	I	Sh.	Eg.	26	7	30	I	Sh.	Eg.
	11	47	III	Oc.	Dis.	28	7	55	III	Tr.	In.
	14	43	III	Ec.	Re.		9	56	III	Tr.	Eg.
14	11	37	II	Tr.	In.		10	24	III	Sh.	In.
	12	16	II	Sh.	In.		12	38	III	Sh.	Eg.
	14	15	II	Tr.	Eg.	30	10	27	II	Oc.	Dis.

Note.—In., denotes ingress; Eg., egress; Dis., disappearance; Re., reappearance; Ec., eclipse; Oc., occultation; Tr., transit of the satellite; Sh., transit of the shadow.

VARIABLE STARS.

Approximate Magnitudes of Variable Stars on Apr. 1, 1912.

[Communicated by the Director of Harvard College Observatory, Cambridge, Mass.]

Name.	R. A. 1900. h	m	Decl. 1900. °	′	Magn.	Name.	R.A. 1900. h	m	Decl. 1900. °	′	Magn.
X Androm.	0	10.8	+46	27	<12	R Arietis	2	10.4	+24	35	8.8*d*
T Androm.		17.2	+26	26	12.5*d*	W Androm.		11.2	+43	50	<13
T Cassiop.		17.8	+55	14	9.6 *i*	Z Cephei		12.8	+81	13	<13
U Cassiop.		40.8	+47	43	13.0*d*	*o* Ceti		14.3	− 3	26	8.1 *i*
RW Androm.		41.9	+32	8	11.8*d*	RR Persei		21.7	+50	49	<14
RV Androm.		47.1	+46	53	<10	RR Cephei		29.4	+80	42	13
W Cassiop.		49.0	+58	1	9.2*d*	R Triang.		31.0	+33	50	11.8
U Androm.	1	9.8	+40	11	<11	W Persei		43.2	+56	34	9.5
— Androm.		10.4	+41	12	13.5*d*	U Arietis	3	5.5	+14	25	8.8*d*
S Cassiop.		12.3	+72	5	10.3*d*	X Ceti		14.3	− 1	26	<11
RL Persei		23.6	+50	20	<14	Y Persei		20.9	+43	50	9.1
RU Androm.		32.8	+38	10	<13	R Persei		23.7	+35	20	12.3 *i*
Y Androm.		33.7	+38	50	9.6*d*	R Tauri	4	22.8	+ 9	56	<12
X Cassiop.		49.8	+58	46	11.2	W Tauri		22.2	+15	49	12 0*d*

Approximate Magnitudes of Variable Stars on Apr. 1, 1912.

Continued.

Name.	R. A. 1900. h	m	Decl. 1900. °	′	Magn.	Name.	R. A. 1900. h	m	Decl. 1900. °	′	Magn.
S Tauri	4	23.7	+ 9	44	<11	S Leonis	11	5.7	+ 6	0	11.4 *i*
T Camelop.		30.4	+65	57	9.0	R ComæBer		59.1	+19	20	<13
RX Tauri		32.8	+ 8	9	10.3	T Virginis	12	9.5	− 5	29	<11
— Tauri		32.8	+ 8	9	12	R Corvi		14.4	−18	42	<10
X Camelop.		32.6	+74	56	10.8 *i*	SS Virginis		20.1	+ 1	19	8.0
V Tauri		46.2	+17	22	9.8	T Can. Ven.		25.2	+32	3	<12
R Orionis		53.6	+ 7	59	10.3*d*	Y Virginis		28.7	− 3	52	<11
R Leporis		55.0	−14	57	7.0	T Urs. Maj.		31.8	+60	2	7.3
V Orionis	5	0.8	+ 3	58	10.2 *i*	R Virginis		33.4	+ 7	32	10.8*d*
T Leporis		0.6	−22	2	11.0	RV Draconis		33.2	+66	8	<13
R Aurigae		9.2	+53	28	11.4 *i*	RS Urs. Maj.		34.4	+59	2	<13
S Aurigae		20.5	+34	4	10.6*d*	S Urs. Maj.		39.6	+61	38	8.6
W Aurigae		20.1	+36	49	<12	U Virginis		46.0	+ 6	6	10.4
S Camelop.		30.2	+68	45	8.0	RV Virginis	13	2.7	−12	38	<12
RR Tauri		33.3	+26	19	11.7	R Hydrae		24.2	−22	46	7.2*d*
U Aurigae		35.6	+31	59	9.3*d*	S Virginis		27.8	− 6	41	10.7
SU Tauri		43.2	+19	2	9.8	RV Urs.Maj.		29.4	+54	31	10.5
SV Tauri		45.8	+28	5	10.2	T Urs.Min.		32.6	+73	56	10.0 *i*
Z Tauri		46.7	+15	46	<12	R Can. Ven.		44.6	+40	2	11.6
U Orionis		49.9	+20	10	9.0	Z Boötis	14	1.7	+13	59	<12
V Camelop.		49.4	+74	30	<13	U Urs. Min.		15.1	+67	15	9.1 *i*
Z Aurigae		53.6	+53	18	9.9	S Boötis		19.5	+54	16	11.7*d*
RW Gemin.		55.4	+23	8	9.3	RS Virginis		22.3	+ 5	8	12
RZ Gemin.		56.6	+22	15	10.3	V Boötis		25.7	+39	18	8.2
X Aurigae	6	4.4	+50	15	11	R Camelop.		25.1	+84	17	11.4*d*
V Monoc.		17.7	− 2	9	10.5	R Boötis		32.8	+27	10	7.5
U Lyncis		31.8	+59	57	<14	RT Librae	15	0.8	−18	21	<11
S Lyncis		35.9	+58	0	<13	Y Librae		6.4	− 5	38	8.6 *i*
X Gemin.		40.7	+30	23	<11	S Cor.Bor.		17.3	+31	44	8.1
RX Gemin.		43.6	+33	21	9.1	S Librae		15.6	−20	2	8.6
W Monoc.		47.5	− 7	2	<11	S Serpentis		17.0	+14	40	9.1
RU Monoc.		49.4	− 7	28	<11	RU Librae		27.7	−14	59	<11
Y Monoc.		51.3	+11	22	10.7	S Urs.Min.		33.4	+78	58	10.9
R Lyncis		53.0	+55	28	9.7	U Librae.		36.2	−20	52	<11
RS Gemin		55.2	+30	40	12.5	R Cor. Bor.		44.4	+28	28	7.7
V Can. Min.	7	1.5	+ 9	2	<14	X Cor. Bor.		45.2	+36	35	<12
R Gemin.		1.3	+22	52	<11	Z Cor.Bor.		52.2	+29	32	<11
R Can. Min.		3.2	+10	11	10.1	Z Scorpii	16	0.1	−21	28	<12
RR Monoc.		12.4	+ 1	17	12.5*d*	RU Herculis		6.0	+25	20	<11
S Can. Min.		27.3	+ 8	32	.8.1	W Cor.Bor.		11.8	+38	3	<11
U Puppis		56.1	−12	34	<11	U Herculis		21.4	+19	7	9.7
R Cancri	8	11.0	+12	2	10.2	R Urs. Min.		31.3	+72	28	10.0
V Cancri		16.0	+17	36	9.3	R Draconis		32.4	+66	58	6.9
RT Hydrae		24.7	− 5	59	8.2	S Herculis		47.4	+15	7	9.0
U Cancri		30.0	+19	14	<14	R Ophiuchi	17	2.0	−15	58	7.4
X Urs Maj.		33.7	+50	30	<12	V Draconis		56.3	+54	53	12.1*d*
S Hydrae		48.4	+ 3	27	11.5	T Herculis	18	5.3	+31	0	<11
T Hydrae		50.8	− 8	46	10.5	W Draconis		5.4	+65	56	<12
T Cancri		51.0	+20	14	9.0	X Draconis		6.8	+66	8	<11
V Urs.Maj.	9	1.2	+51	31	10.6	SV Draconis		31.2	+49	18	<13
X Hydrae		30.7	−14	15	11.6	X Ophiuchi		33.6	+ 8	44	8.1*d*
Y Draconis		31.1	+78	18	12.4*d*	RY Lyrae		41.2	+34	34	<13
R Leo. Min.		39.6	+34	58	10.3*d*	R Scuti		42.2	− 5	49	6.0
RR Hydrae		40.4	−23	34	<12	Z Lyrae		56.0	+34	49	<13
R Leonis		42.2	+11	54	6.3	V Lyrae	19	5.2	+29	30	<10
V Leonis		54.5	+21	44	9.0	S Lyrae		9.1	+25	50	<14
R Urs. Maj.	10	37.6	+69	18	11.6*d*	UDraconis		9.9	+67	7	<12
W Leonis		48.4	+14	15	<13	TZ Cygni		13.4	+50	0	11.8*d*

Approximate Magnitudes of Variable Stars on Apr. 1, 1912—Con.

Name.	R. A. 1900. h	m	Decl. 1900. °	′	Magn.	Name.	R.A. 1900 h	m	Decl. 1900 °	′	Magn.
U Lyrae	19	16.6	+37	42	11.9*d*	RVulpeculae	20	59.9	+23	26	8.2
R Cygni		34.1	+49	58	10.5*d*	X Cephei	21	3.6	+82	40	<13
RT Cygni		40.8	+48	32	8.1	T Cephei		8.2	+68	5	9.8
TU Cygni		43.3	+48	49	<10	S Cephei		36.5	+78	10	8.3
X Cygni		46.7	+32	40	<11	S Lacertae	22	24.6	+39	48	<12
R Delphini	20	10.1	+ 8	47	<11	R Lacertae		38.8	+41	51	11.8 *i*
SX Cygni		11.6	+30	46	11.5*d*	V Cassiop.	23	7.4	+59	8	11.0*d*
V Sagittae		15.8	+20	47	12.0	Z Cassiop.		39.7	+56	2	<13
U Cygni		16.5	+47	35	7.1	R Cassiop.		53.3	+50	50	<11
ST Cygni		29.9	+54	38	<11	Y Cassiop.		58.2	+55	7	<13
S Delphini		38.5	+16	44	9.3	SV Androm.		59.2	+39	33	9.2
RZ Cygni		48.5	+46	59	<12						

The letter *i* denotes that the light is increasing; the letter *d*, that the light is decreasing; the sign <, that the variable is fainter than the appended magnitude. The above magnitudes have been compiled at the Harvard College Observatory from observations made by the following observers:— T. C. H. Bouton, C. E. Furness, Edward Gray, M. Harwood, F. E. Hathorn, C. J. Hudson, M. W. Jacobs, Jr., W. T. Olcott, P. G. O'Reilly, P. R.Sutton, David Todd, H. W. Vrooman, I. E. Woods, J. B. Lacchini, E. L. Forsyth, E. R. Padova, E. A. Perkins, S. E. Hunter and A. S. Young.

Minima of Variable Stars of the Algol Type.

[Calculated by Mary H. Wilson at Goodsell Observatory.]

Given to the nearest hour in Greenwich mean time; to obtain Eastern Standard time subtract 5^h; Central Standard 6^h, etc.

Star	R. A. 1900 h	m	Decl. 1900 °	′	Magnitude	Approx. Period d	h	Greenwich mean times of minima in **June** 1912. d h	d h	d h	d h	d h
SY Androm.	0	08.0	+43	09	9.5—13.0	34	21.6	2 20				
UU Androm.		38.5	+30	24	10.7—11.9	1	11.7	5 14;	11 12;	23 10;	29 8	
U Cephei	0	53.4	+81	20	7.1— 9.2	2	11.8	2 24;	12 23;	22 22;	27 22	
Z Persei	2	33.7	+41	46	9.4—12.	3	01.4	1 5;	7 7;	19 13;	25 15	
RY Persei		39.0	+47	43	8.0—10.3	6	20.7	1 3;	7 23;	21 17;	28 14	
RZ Cassiop.		39.9	+69	13	6.4— 7.8	1	04.7	1 21;	7 21;	19 20;	25 19	
ST Persei		53.7	+38	47	8.5—10.5	2	15.6	3 13;	14 3;	24 17;	30 0	
RX Cephei	2	58.8	+67	11	8.6— 9.1	32	07.6		25 8			
Algol	3	01.7	+40	34	2.3— 3.5	2	20.8	3 16;	9 10;	20 21;	26 15	
RT Persei		16.7	+46	12	9. —11.	0	20.4	2 6;	12 11;	22 15;	27 18	
λ Tauri		55.1	+12	12	3.4— 4.5	3	22.9	7 22;	15 19;	23 17		
RW Tauri	3	57.8	+27	51	7.1—<11	2	18.5	6 6;	11 19;	22 21;	28 10	
RV Persei	4	04.2	+33	59	10.6—12.8	1	23.4	3 2;	8 24;	20 20;	26 18	
RW Persei		13.3	+42	04	8.8—11.0	13	04.8	2 3;	15 8;	28 13		
RS Cephei	4	48.6	+80	06	9.5—12.2	12	10.1	8 9;	20 19			
RY Aurigæ	5	11.5	+38	13	10.7—11.7	2	17.5	2 18;	13 16;	24 14;	30 1	
RZ Aurigæ		42.9	+31	40	10.6—13.3	3	00.3	3 18;	9 19;	21 20;	27 20	
SV Gemin;		54.6	+24	28	9.8—<11	4	00.2	6 1;	14 1;	22 1;	30 2	
RW Gemin.	5	55.4	+23	08	9.5—11.0	2	20.8	6 15;	12 9;	23 20;	29 13	
U Columbæ	6	11.2	−33	03	9.4—10.2	2	19.2	5 19;	11 10;	24 15;	28 5	
56,1908 Gemin.		22.	+20	37	10.8—11.5	1	08.8	2 4;	13 2;	24 1;	29 12	
RW Monoc.		29.3	+ 8	54	9.0—10.8	1	21.7	2 5;	9 20;	17 11;	25 2	
RX Gemin.		43.6	+33	21	8.8— 9.6	12	05.0	3 2;	15 7;	27 12		
RU Monoc.	6	49.4	− 7	28	9.8—10.5	0	21.5	6 2;	11 11;	22 5;	27 14	
R Canis Maj.	7	14.9	−16	12	5.9— 6.7	1	03.3	4 20;	10 12;	21 21;	27 13	

Minima of Variable Stars of the Algol Type.—Continued.

Star	R. A. 1900 h m	Decl. 1900 ° ′	Magnitude	Approx. Period d h	Greenwich mean times of minima in **June** 1912. d h	d h	d h	d h	d h
RY Gemin.	17 21.7	+15 52	8.9—<10	9 07.2	5 5;	14 12;	23 19		
Y Camelop	27.6	+76 17	9.5—12.	3 07.3	5 1;	11 15;	18 6;	24 21	
RR Puppis	43.5	−41 08	9.5—	6 10.3	1 3;	7 13;	20 10;	26 20	
V Puppis	7 55.4	−48 58	4. — 5.	1 10.9	4 28;	12 11;	19 17;	26 24	
X Carinæ	8 29.1	−58 53	7.8— 8.9	0 13.0	3 9;	14 4;	25 0;	30 10	
S Cancri	8 38.2	+19 24	8. —10.	9 11.6	7 23;	17 10;	26 22		
S Velorum	9 29.5	−44 46	7.8— 9.5	5 22.4	6 8;	12 7;	24 3;	30 2	
Y Leonis	9 31.1	+26 41	9.3—11.2	1 16.5	1 4;	9 15;	18 1;	26 11	
RR Velorum	10 17.8	−41 36	10.0—10.9	1 20.5	1 10;	10 16;	19 23;	29 05	
SS Carinæ	10 54.2	−61 23	12.2—12.8	3 07.2	6 9;	12 23;	19 13;	26 4	
RW Urs. Maj	11 35.4	+52 34	9.3—10.3	7 07.9	4 23;	12 7;	19 15;	26 23	
Z Draconis	11 40.6	+72 49	9.5—12.5	1 08.6	3 9;	10 4;	23 17;	30 12	
SS Centauri	13 07.2	−63 37	8.8—10.4	2 11.5	6 18;	14 4;	21 15;	29 1	
δ Libræ	14 55.6	− 8 07	5. — 6.7	2 07.9	2 20;	9 19;	23 18;	30 18	
U Coronæ	15 14.1	+32 01	7.8— 9.0	3 10.9	4 2;	11 0;	17 22;	24 20	
TW Draconis	15 32.4	+64 14	7.0— 8.9	2 19.4	9 5;	17 15;	26 1		
SW Ophiuchi	16 11.1	− 6 44	9.2—10.	2 10.7	3 24;	11 8;	18 16;	25 24	
SX Ophiuchi	16 12.6	− 6 25	10.5—11.2	2 01.5	4 22;	11 2;	23 12;	29 16	
R Araæ	16 31.1	−56 48	6.7— 8.	4 10.2	2 15;	11 11;	20 7;	29 4	
TT Herculis	16 49.9	+17 00	8.9— 9.5	20 18.1		10 12			
TU Herculis	17 09.8	+30 50	9.5—12.	2 06.4	7 11;	14 6;	21 1;	27 20	
U Ophiuchi	11.5	+ 1 19	6. — 6.7	0 20.1	9 4;	17 13;	25 22		
SZ Herculis	36.0	+33 01	9.5—10.3	0 19.6	4 18;	12 22;	21 2;	29 7	
Z Herculis	17 53.6	+15 09	6.7— 8.0	3 23.8	8 14;	16 14;	24 14		
SX Draconis	18 03.0	+58 23	9.3—10.5	5 04.1	3 0;	13 8;	23 17;	28 21	
RS Sagittarii	11.0	−34 08	6.7— 7.8	2 10.0	3 8;	10 14;	17 20;	25 2	
V Serpentis	11.1	−15 34	9.5—	3 10.9	1 0;	7 22;	21 17;	28 15	
RZ Draconis	21.8	+58 50	9.5—10.2	0 13.2	4 9;	9 21;	20 21;	26 9	
RX Herculis	26.0	+12 32	7.8— 8.0	0 21.3	1 11;	10 8;	19 5;	28 3	
SX Sagittarii	18 39.7	−30 36	8.6— 9.4	2 01.8	6 1;	12 7;	24 18;	30 24	
RR Draconis	40.8	+62 34	9.3—13.	2 19.9	3 16;	12 4;	20 16;	29 4	
RS Scuti	43.7	−10 21	9.3—10.3	0 15.9	2 7;	8 21;	15 11;	28 16	
U Scuti	18 48.9	−12 44	9.0— 9.8	0 22.9	3 11;	13 1;	22 14		
RX Draconis	19 01.1	+58 35	9.3—10.2	1 21.5	2 9;	12 21;	22 8		
RV Lyræ	12.5	+32 15	11. —13.	3 14.4	5 13;	12 17;	19 22;	27 3	
RS Vulpec.	13.4	+22 16	6.9— 8.0	4 11.4	4 17;	13 16;	22 15		
U Sagittæ	14.4	+19 26	6.7— 9.0	3 09.1	3 16;	10 11;	23 23;	30 18	
Z Vulpec.	17.5	+25 23	7.3— 8.5	2 10.9	7 20;	15 5;	22 14;	29 23	
136.1910 Lyræ	24.3	+41 30	9.0<11.0	5 05.8	6 1;	11 7;	21 18;	27 0	
SY Cygni	19 42.7	+32 28	10. —12.	6 00.2	3 22;	9 22;	21 23;	27 23	
WW Cygni	20 00.6	+41 18	9.5—12.5	3 07.6	1 20;	8 12;	21 18;	28 9	
SW Cygni	03.8	+46 01	9. —12.	4 13.8	7 4;	16 8;	25 11		
VW Cygni	11.4	+34 12	9.5—11.5	8 10.3	6 16;	15 2;	23 12		
RW Capric.	12.2	−17 59	8.8—10.6	3 09.4	1 12;	8 7;	21 21;	28 15	
UW Cygni	19.6	+42 55	10.5—13.	3 10.8	1 13;	8 11;	22 6;	29 4	
W Delphini	33.1	+17 56	9.5—11.5	4 19.4	4 3;	13 18;	23 9		
RR Delphini	38.9	+13 35	10.5—11.8	4 14.4	9 5;	18 9;	27 14		
Y Cygni	48.1	+34 17	7. — 8.	1 12.0	7 13;	15 1;	22 12;	30 0	
RR Vulpec.	20 50.5	+27 32	9.6—11.0	5 01.2	6 0;	11 2;	21 4;	26 5	
VV Cygni	21 02.3	+45 23	11. —14.	1 11.4	6 0;	13 9;	20 19;	28 4	
AE Cygni	09.0	+30 20	10.8—11.4	0 23.3	7 19;	17 12;	27 5		
UZ Cygni	55.2	+43 52	9. —11.5	31 07.3	8 19				
RT Lacertæ	21 57.4	+43 24	9.1—10.5	5 01.7	4 21;	15 0;	25 4;	30 6	
RW Lacertae	22 40.6	+49 08	10.2—11.2	5 04.4	5 13;	10 18;	21 2;	26 7	
TT Androm	23 08.7	+45 36	10.5—11.3	2 18.3	8 13;	16 20;	25 3		
32.1911 Piscium	29.3	+ 7 22	9.0—12.0	3 18.4	2 17;	10 6;	17 19;	25 8	
TW Androm.	23 58.2	+32 17	8.6—11.5	4 02.9	6 20;	15 2;	23 8		

Maxima of Variable Stars of Short Period not of the Algol Type.

[Calculated by Wallace F. Johnson at Goodsell Observatory]

Given to the nearest hour in Greenwich mean time. To obtain Eastern standard time subtract 5^h; Central standard time 6^h etc. An * following the name of a star signifies that for that star times of minima instead of maxima are given.

Star	R. A. 1900 h m	Decl. 1900 ° ′	Magnitude	Approx. Period d h	Greenwich mean times of maxima in June 1912. d h d h d h d h
SX Cassiop.	0 05.5	+54 20	8.6— 9·4	36 13.7	3 9
SY Cassiop.	9.8	+57 52	9 3— 9.9	4 1.7	1 22; 10 1; 18 4; 26 8
RT Sculptor.*	0 31.5	−26 13	9.6—10.5	0 12.3	4 2; 9 5; 19 10; 29 16
RR Ceti	1 27.0	+ 0 50	8.3— 9.0	0 13.3	4 17; 10 5; 21 7; 26 20
RW Cassiop.	1 30.7	+57 15	8.6— 9.4	14 19 2	9 17; 24 12
V Arietis	2 09.6	+11 46	8.3— 9.0	0 23.8	3 8; 9 7; 21 5; 27 4
RUCassiop.	2 43.0	+68 28	6.5— 7.0	1 22.8	5 19; 11 15; 29 9; 29 5
TU Persei	3 01.8	+52 49	11.4—12.2	0 14.6	5 10; 11 11; 23 15; 29 17
RW Camelop.	3 46.2	+58 21	8.2— 9.4	16 00.0	15
SX Persei	4 10.2	+41 29	10.3—11.0	4 07.1	7 14; 16 4; 24 18
SV Persei	42.8	+42 07	8.8— 9.6	11 03.1	1 13; 12 16; 23 19
RX Aurigæ	4 54.5	+39 49	7.2— 8.1	11 15.0	5 13; 17 4; 28 19
TT Aurigæ*	02.8	+39 27	7.8— 8.7	0 16.0	5 0; 11 16; 18 8; 25 0
SX Aurigæ	5 04.6	+42 02	8.0— 8.7	1 12.8	2 13; 8 16; 20 22; 27 1
SYAurigæ	05.5	+42 42	9.0— 9.7	10 03.3	2 17; 12 20; 22 23
Y Aurigæ	21.5	+42 21	9. —	3 20.6	3 12; 11 5; 18 22; 26 15
SVTauri*	45.8	+28 05	9.4—11.0	2 04.0	6 23; 13 11; 19 23; 26 11
RZ Gemin.	5 56.6	+22 15	9.1—10.0	5 12.7	3 0; 8 13; 19 14; 30 16
RS Orionis	6 16.5	+14 43	7·8— 8.5	7 13.4	4 12; 12 2; 19 15; 27 5
T Monoc.	19.8	+ 7 08	6. — 8.	27 00.3	20 3
RZ Camelop	23.7	+67 06	11.0—12.8	0 11.5	5 0; 9 20; 19 10; 29 1
W Gemin.	29.2	+15 24	6 8— 7.6	7 22.0	5 14; 13 12; 21 10; 29 8
ξ Gemin.	6 58.2	+20 43	3.7— 4.5	10 03.7	1 16; 11 19; 21 23
RU Camelop.	7 10.9	+69 51	8.5— 9.8	22 06.5	3 12; 25 18
RR Gemin.	7 15.2	+31 04	9.7—10.6	0 09.5	2 14; 10 13; 18 11; 26 10
V Carinæ	8 26.7	−59 47	7.2— 8.0	6 16.7	5 9; 12 1; 18 18; 25 11
T Velorum	8 34.4	−47 01	7.5— 8.5	4 15.3	1 7; 10 13; 19 20; 29 3
W Carinæ	9 19.2	−55 32	7.5— 8.5	4 08.9	4 15; 13 9; 22 3; 30 21
S Antliæ*	27.9	−28 11	6.7— 7.8	0 07.8	4 22; 11 10; 24 9; 30 21
W Ursæ Maj.	9 36.7	+56 24	8.	0 04.0	5 0; 11 16; 18 9; 25 1
RR Leonis	10 02.1	+24 03	9.1—10.0	0 10.9	4 15; 9 9; 18 21; 28 9
ST Ursæ Maj.*	11 22.4	+45 44	6.7— 7.2	8 19.2	3 19; 12 14; 21 10; 30 5
SU Draconis	11 32.2	+67 53	8.9— 9.6	0 15.8	1 3; 7 18; 20 23; 27 13
S Muscae	12 07.4	−69 36	6.5— 7.3	9 15.8	4 8; 13 23; 23 15
SW Draconis	12.8	+70 04	8.8— 9.6	0 13.7	4 16; 10 8; 21 18; 27 11
T Crucis	15.9	−61 44	6.8— 7.6	6 17.6	5 2; 11 20; 18 13; 25 7
R Crucis	18.1	−61 04	6.8— 8.0	5 19.8	5 3; 10 23; 22 14; 28 10
S Crucis	48.4	−57 53	6.6— 7.8	4 16.6	3 8; 8 1; 17 10; 26 19
RZ Centauri	12 55.6	−64 05	8.5— 8.9	0 22.5	2 2; 9 14; 17 2; 24 14
W Virginis	13 20.9	− 2 52	9.0—10.0	17 06.5	10 21; 28 3;
RV Urs. Maj.	13 29.4	+54 31	9.2— 9.9	0 11.2	6 12; 13 12; 20 13; 27 13
ST Virginis	14 22.5	− 0 27	10.3—11.4	0 09.9	1 6; 9 11; 17 16; 25 21
V Centauri	25.4	−56 27	6.7— 7.6	5 11.9	4 0; 9 12; 20 12; 26 0
RS Bootis	29.3	+32 11	8.9—10.	0 09.1	2 15; 10 4; 17 17; 25 6
RU Bootis	14 41.5	+23 44	12.8—14.3	0 11.9	1 19; 9 5; 16 15; 24 1
RTriang.Austr	15 10.8	−66 08	6.7— 7.7	3 09.3	2 15; 9 9; 22 23; 29 17
STriang.Austr	15 52.2	−63 29	6.5— 7.5	6 07.8	3 2; 9 10; 22 1; 28 9
S Normæ	16 10.6	−57 39	6.5— 7.4	9 18.1	10 9; 20 3; 29 21
RW Draconis	33.7	+58 03	9.6—10.8	0 10.6	5 23; 14 20; 23 16
RV Scorpii	16 51.8	−33 27	6.8— 7.6	6 01.5	6 14; 12 15; 24 18; 30 20
u Herculis*	17 13.6	+33 12	5.1— 5.6	2 01.2	1 12; 7 16; 19 23; 26 3

Maxima of Variable Stars of Short Period not of the Algol Type.

Continued.

Star	R. A. 1900	Decl. 1900	Magnitude	Approx. Period	Greenwich mean time of maxima in June 1912.
	h m	° ′		d h	d h d h d h d h
RV Ophiuchi*	17 29.8	+ 7 19	9.—< 11	3 16.5	7 21; 15 6; 22 15; 30 0
X Sagittarii	41.3	−27 48	4.0— 6.0	7 00.3	2 14; 9 14; 23 15; 30 15
Y Ophiuchi	47.3	− 6 07	6.2— 7.0	17 02.9	11 21; 29 0
W Sagittarii	17 58.6	−29 35	4.8— 5.8	7 14.3	3 14; 11 4; 18 18; 26 9
Y Sagittarii	18 15.5	−18 54	5.8— 6.6	5 18.6	2 21; 8 16; 20 5; 25 23
U Sagittarii	26.0	−19 12	7.0— 8.3	6 17.9	1 6; 8 0; 21 11; 28 5
Y Scuti	32.6	− 8 27	8.7— 9.2	10 08.3	1 21; 12 5; 22 14
Y Lyrae	34.2	+43 52	10.5—12.	0 12.1	6 14; 12 15; 24 17; 30 18
RZ Lyrae	39.9	+32 42	9.9—11.2	0 12.3	5 17; 10 20; 21 1; 26 4
RT Scuti	44.1	−10 30	9.1— 9.7	0 11.9	4 0; 8 23; 18 21; 28 19
β Lyrae *	46.4	+33 15	3.4— 4.5	12 21.8	12 3; 25 1
κ Pavonis	18 46.9	−67 22	4.0— 5.5	9 02.2	3 0; 12 2; 21 5; 30 7
U Aquilae	19 24.0	− 7 15	6.4— 7.1	7 00.6	7 6; 14 6; 21 7; 28 7
XZ Cygni	30.4	+56 10	8.7— 9.3	0 11.2	3 7; 7 23; 17 7; 26 15
U Vulpec.	32.2	+20 07	6.9— 7.6	7 23.5	8 21; 16 20; 24 20
SU Cygni	40.8	+29 01	6.6— 7.4	3 20.3	1 22; 9 15; 17 7; 25 0
η Aquilae	47.4	+ 0 45	3.5— 4.7	7 04.2	2 11; 9 15; 16 19; 24 0
S Sagittae	51.5	+16 22	5.6— 6.4	8 09 2	9 1; 17 10; 25 19
X Vulpec.	19 53.3	+26 17	8.5— 9.1	6 07.7	1 16; 8 0; 20 15; 26 23
XX Cygni	20 01.3	+58 40	10.5—11.5	0 03.2	5 20; 12 14; 19 8; 26 2
V Vulpec. *	32.3	+26 15	8.0— 9.0	37 19.0	
X Cygni	39.5	+35 14	6.4— 7.7	16 09 3	9 10; 25 19;
T Vulpec.	47.2	+27 52	5.5— 6.5	4 10 5	4 22; 9 9; 18 6; 27 3
WZ Cygni *	49.3	+38 27	9.8—10.8	0 14.0	5 16; 11 12; 23 5; 29 1
WY Cygni	52.3	+30 03	9.5—10.3	0 13.5	3 8; 8 22; 20 4; 25 18
RV Capric.	55.9	−15 37	9.2—10.1	0 10.7	4 12; 8 23; 17 22; 26 21
TX Cygni	20 56.4	+42 12	8.5— 9.7	14 17.4	7 2; 21 19
VY Cygni	21 00.4	+39 34	8.9— 9.5	7 20.6	7 19; 15 16; 23 13
VZ Cygni	21 47.7	+42 40	8.4— 9.2	4 20.7	2 22; 7 19; 17 12; 27 5
Y Lacertae	22 05.2	+50 33	9.1— 9.6	4 07.6	8 5; 16 20; 25 12
δ Cephei	25.5	+57 54	3.7— 4.9	5 08.8	4 6; 9 15; 20 8; 25 17
Z Lacertae	36.9	+56 18	8.2— 9.0	10 21.1	9 11; 20 8
RR Lacertae	37.5	+55 55	8.5— 9.2	6 10.1	2 23; 9 9; 22 5; 28 15
V Lacertae	44.5	+55 48	8.2— 8.9	4 23.6	2 17; 7 17; 17 16; 27 15
X Lacertae *	22 45.0	+55 54	8.2— 8.6	5 10.6	3 2; 8 12; 19 10; 30 7
SW Cassiop.	23 03.7	+58 12	9.2— 9.7	5 10.6	4 17; 10 4; 21 1; 26 11
RS Cassiop.	32.6	+61 52	9.1—10.0	6 07.1	1 7; 7 15; 20 5; 26 12
RY Cassiop.	47.2	+58 11	9.2—10.0	12 03.4	10 12; 22 16
U Pegasi	23 52.9	+15 24	9.0— 9.7	0 04.5	7 16; 15 4; 22 16; 30 3

Nova Geminorum.—On March 12, 1912 at about 13^h 30^m G. M. T. I set for a class in elementary astronomy the task of making a chart of the constellation Gemini including all stars visible to the naked eye in or near the quadrilateral $\alpha\ \beta\ \gamma\ \mu$. Contrary to custom no attempt was made to arrange the stars in order of magnitude. On my own chart and on some of those by the students the star which turned out to be Nova appears. Others fail to record it but all record the stars ι and υ and some record b. I remember especially that d and ω were difficult to see. Nova however left no such impression, but then neither did 3.5. Among the twenty-five stars charted were:

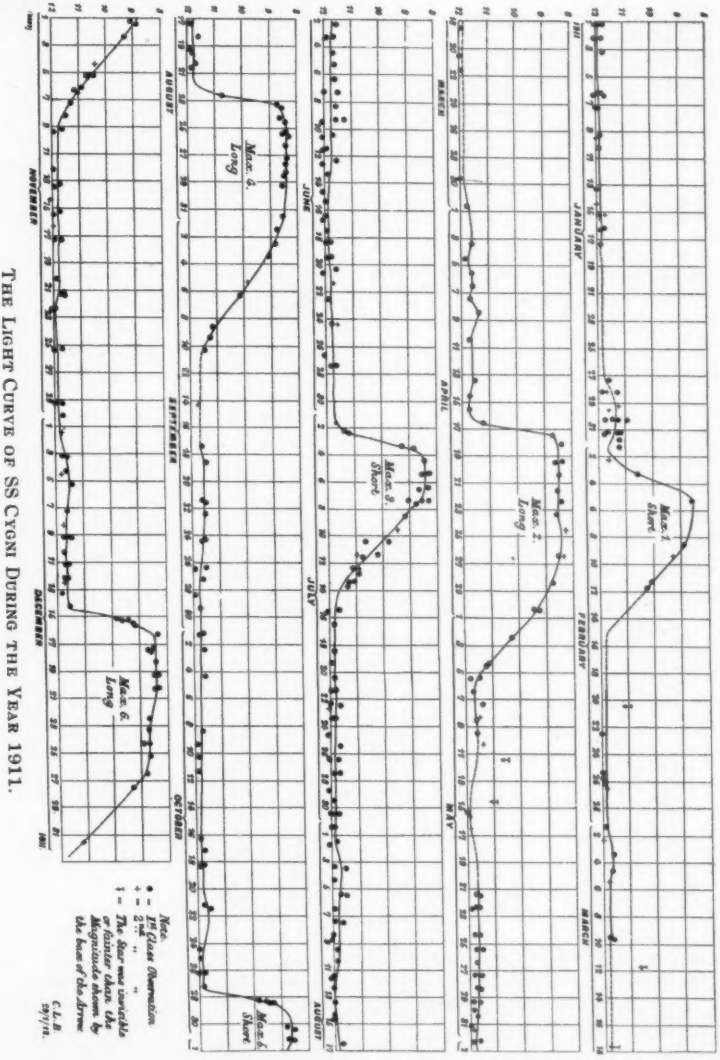
Star	θ	ι	d	ρ	σ	τ	υ	ω	A	b	30	35
Mag	3.64	3.89	5.22	4.18	4.26	4.48	4.22	5.21	5.08	5.09	4.65	5.90

It seems a warranted conclusion that at the time of observation Nova was between the fourth and fifth magnitude, probably near the fifth.

F. W. Reed.

Urbana, Ill., Apr. 4, 1911.

Light Curve of SS Cygni.—The accompanying illustration is taken from the *Journal of the British Astronomical Association* for March 1912, and shows the light changes of this wonderful variable during the year 1911. As will appear from the diagram the star has two types of maximum (long and short) which alternate with each other, the long maximum lasting six or seven days and the short one about half that time. The rise in brightness is very rapid in both cases and the waning much slower. The intervals between maxima are irregular.



THE LIGHT CURVE OF SS CYGNI DURING THE YEAR 1911.

Nova Geminorum No. 2.—A letter dated March 23, 1912, has been received at this Observatory from Professor Frost stating that excellent slit spectrograms of Nova Geminorum No. 2, taken since March 16 by Mr. Barrett, show no evidence of the nebular lines. There is not a trace of a line to be seen at the position of the second nebular line λ 4959, while at λ 5007 there is a bright line in the vicinity. It is probably associated with λ 5016 (He) which is strong.

Professor Barnard measured with the micrometer of the 40-inch a star of about the 14th magnitude, in position angle 17°, distance 12″, with respect to the Nova.

The first observation taken at Yerkes of the typical Nova spectrum was on March 15, not 14.

Professor Hussey writes that five plates of the spectrum of the Nova, obtained by Dr. Curtiss on March 13, are not of the F5 type, but, as stated in his telegram, of the usual Nova maximum type.

The characteristics shown by these plates which characterize the spectrum as that of the Nova type, are the following: strong displacements of the absorption lines of hydrogen, helium and calcium towards the violet; emission associated with these lines, more extensive on the red edge, and sharply reversed in the case of calcium.

Spectra taken recently show emission on both sides of the displaced absorption lines of hydrogen, which indicates that in Nova spectrum the emission is not confined to the red edge of the absorption lines.

EDWARD C. PICKERING.

Astronomical Bulletin No. 491.
Harvard College Observatory.
Cambridge, Mass., March 26, 1912.

Nova Geminorum.—The new star is still visible with the aid of field-glasses. Since April 8 it has diminished very little in brightness, remaining at about magnitude 6.2.

The following observations were made by H. C. Wilson with 2-inch field glasses. There is a little uncertainty as to the magnitude of some of the comparison stars, so that the results will have to be revised later. The magnitudes are probably correct on my scale within 0m.2.

				m
March	26	8:00	C.S.T.	5.6
		10:00	"	5.6
	28	10:20	"	5.9
April	2	9:40	"	5.7
	3	9:10	"	5.6
	8	8:48	"	6.2
	9	10:00	"	6.2
	10	9:00	"	6.2
	18	9:50	"	6.2
	19	10:25	"	6.2

NOTES FOR OBSERVERS.

Mr. H. L. Thomas, of Stuart, Nebraska, has resigned the directorship of the Nebula and Star Cluster Section of the S. P. A., and Mr. R. L. Doherty of Palmyra, Mo., will undertake the duties of directing that section.

The Monthly Report of the American Association of Variable Star Observers.—The past month has been exceptionally interesting to variable star observers, for in addition to the appearance of a lucid Nova, a phenomenon of rare importance, three of the most interesting long period variable stars known have shown activity. These stars are 074922 U Geminorum, 154428 B Corona Borealis, and 213843 SS Cygni, and especial attention is called to the observations of them herein recorded. The rapid and mysterious fluctuations in the light of these enigmatic stars furnish material that is both fascinating for all interested in observational astronomy, and most practical for those who would use their telescopes to good advantage.

Unquestionably the event of the month, astronomically speaking, was the discovery of Nova Geminorum by the astronomer Enebo, in Norway, March 12. The history of the star to March 16 appeared in "POPULAR ASTRONOMY" for April. The star appears to have reached a maximum of approximately 3.5 magnitude about March 14; it then waned to the sixth magnitude during the next two days. Three of our observers made estimates of the star from March 16 to 22, the result showing that after this decrease in light the star brightened almost a magnitude in the week following the sixteenth, much as a dying ember suddenly flashes forth, quickened into life by some current of air that fans it.

True to the prediction in the last report, 074922 U Geminorum leaped into visibility in small telescopes during the past month, and was observed by a number of our observers, with estimates well in accord. It reached a maximum of approximately magnitude 9.1, and held it for about a week, sinking quickly in a week following the fifteenth to a faint star scarcely visible in a three-inch telescope.

Hartwig's calculated maximum of 163266 R Draconis for March 25 was close to the observed date of maximum by a number of our observers. The variable reached approximately the 7th magnitude at maximum.

The observations of 103769 Ursae Majoris call for special comment, owing to the remarkable agreement of the observations of Messrs. Bouton, Forsyth, and Gray on March 22, each observer estimating it to be an eleventh magnitude star. Such close work as this cannot help but be most gratifying to the participants and to those plotting the curves of these interesting stars.

The sudden rise of 054920 U Orionis the first week in April is noteworthy.

Special attention is called to the following notice:—

Will our observers who are observing the variable 123961 S Ursae Majoris, kindly make as many observations of this star as possible until otherwise advised. It is advisable for those not observing this star to annex it to their list at the first opportunity, and observe it frequently.

It is a pleasure to welcome to our ranks Mr. Charles Y. McAteer, of Pittsburg, Pa., whose oservations appear in this report for the first time. The letter "M" indicates observations contributed by Mr. McAteer.

In the past these reports have dated from the 10th inst. As this rule has rendered unavailable many observations made by observers at a distance from headquarters, who had to mail their reports to the secretary several days prior to the 10th, it has been thought wise to alter this plan, and hereafter observations made between the date of sending in the report to the secretary and the 10th inst. will be available for the next report. This rule chiefly applies to those at a distance from Norwich, Conn.

Reports as heretofore must be mailed so as to reach the secretary by the *ninth* of the month.

WILLIAM TYLER OLCOTT.

Norwich, Conn., Apr. 10, 1912.

VARIABLE STAR OBSERVATIONS Mar. 10 to Apr. 10, 1912.

001726
T Andromedae
Mo. Day Est. Obs.
3 16 12.0 Y

001755
T Cassiopeiae
3 13 10.6 J
17 10.4 J
22 10.0 J
22 9.8 Y
30 9.9 J
4 3 9.2 Y

004047
U Cassiopeiae
3 22 12.4 Y

004132
RW Androm.
3 13 11.3 J

004958
W Cassiopeiae
3 13 8.8 J
17 9.1 J
22 9.0 J
30 9.2 J
4 3 9.2 J

011272
S Cassiopeiae
3 13 10.2 J
17 10.3 J
20 10.5 B
30 10.7 J
4 4 11.1 B

013338
Y Androm.
3 17 9.5 J
22 9.6 J
4 3 10.6 J

014958
X Cassiopeiae
3 22 11.3 Y
4 3 11.2 Y

021024
R Arietis
3 10 8.2 O
21 8.5 G

021403
o Ceti
3 7 8.7 F
7 8.6 G
10 9.1 L
11 9.0 L
13 8.8 F
13 9.0 L
18 8.5 F
18 9.6 G
19 8.8 L

023133
R Triang.
Mo. Day Est. Obs.
3 22 11.8 Su
22 11.2 Y
4 3 11.6 Y

024315
W Persei
3 9 9.6 V
16 9.8 V
22 9.2 V

030514
U Arietis
3 22 8.7 Y
4 3 9.4 Y

032043
Y Persei
2 13 9.0 Hu
22 9.3 Su

032335
R Persei
3 16 12.6 Y
22 12.5 Y
4 3 12.0 Y

035916
V Eridani
3 21 8.5 G

042209
R Tauri
3 13 11.8 Su

042215
W Tauri
3 22 11.9 Y
4 3 12.0 Y

043065
T Camelop.
3 16 8.9 Y
22 8.8 Y
4 3 8.2 Y

043274
X Camelop.
3 16 12.3 Y
22 11.4 Y
4 3 10.6 Y

044617
V Tauri
3 13 9.8 Su

045307
R Orionis
3 22 9.9 Y
4 3 10.2 Y

045514
R Leporis
3 4 7.3 F
7 7.1 F
7 7.0 G

R Leporis
Mo. Day Est. Obs.
3 10 7.0 F
13 7.2 F
13 7.9 V
21 7.5 L
21 6.9 G
22 7.2 F
26 7.4 L
27 6.8 G
27 7.1 F
29 7.2 F
4 3 6.5 G

050022
T Leporis
3 13 11.0 G
22 11.0 G

050953
R Aurigae
3 16 12.6 Y
17 12.2 G
22 11.7 J
30 11.5 J
4 3 11.6 Y
4 12.4 Y

052034
S Aurigae
3 16 9.2 Y
4 4 9.1 Y

053068
S Camelop.
3 16 8.0 Y
22 8.0 Y
4 3 8.4 Y

053531
U Aurigae
3 16 8.7 Y
22 8.7 Y
4 4 9.3 Y

054319
SU Tauri
3 22 10.0 Y
4 4 10.6 Y

054920
U Orionis
3 7 10.0 G
16 10.6 Y
22 10.2 Y
4 3 10.2 Y
4 8.9 Hu
6 8.7 O
8 8.2 S

055353
Z Aurigae
3 16 10.0 Y
22 9.7 Y
4 4 9.4 Y

061702
V Monoc.
Mo. Day Est. Obs.
3 9 11.3 Y
16 11.2 V

065355
R Lyncis
3 13 9.1 J
16 9.0 J
17 9.3 J
18 9.2 B
22 9.4 Y
22 9.6 J
25 9.0 B
31 9.6 J
4 3 9.7 J
3 9.9 Y
5 10.4 B

070122
R Gemin.
4 4 12.6 Hu

070310
R Can. Min.
3 8 7.6 G
10 9.3 O
13 9.8 V
19 9.4 V
22 9.5 O
4 5 10.0 V
6 10.5 O

072708
S Can. Min.
3 3 8.8 M
7 8.7 G
10 8.6 L
10 8.7 O
13 8.5 L
13 8.6 M
17 8.2 Ha
17 8.2 M
19 8.6 L
20 8.5 G
21 8.5 L
22 8.6 F
23 8.2 B
23 8.4 L
24 8.1 Ha
27 8.1 G
30 8.3 O
4 2 7.9 Ha
3 7.8 M
3 7.9 B
6 8.1 O
6 8.0 S
6 7.9 Ha

073508
U Can. Min.
3 9 10.5 G
16 11.8 Y
4 4 10.4 Y
8 10.5 G

074922
U Gemin.
Mo. Day Est. Obs.
3 9 9.1 V
9 9.2 J
10 9.1 O
13 9.2 Hu
13 9.1 O
15 9.2 J
16 9.6 Y
16 9.7 J
16 9.8 G
16 9.1 V
17 9.8 J
22 12.5 J
22 12.4 Y

080232
RU Puppis
3 9 9.3 G
20 9.0 G

081112
R Cancri
3 8 10.2 G
10 10.5 F
22 10.2 F
22 10.1 O
4 6 9.9 O

081617
V Cancri
3 8 9.6 G

082405
RT Hydrae
3 10 8.0 O
13 7.6 G
13 8.5 V
19 7.8 V
22 8.0 O
23 8.0 G

084803
S Hydrae
3 13 11.7 O
13 11.7 Hu
22 11.0 O
4 6 10.5 O
8 10.8 Hu

085008
T Hydrae
3 10 9.6 O
13 9.6 G
22 10.5 O
23 10.2 G

085120
T Cancri
3 7 9.0 G
9 8.8 V
10 9.6 L
11 9.6 L
16 9.3 V
22 9.4 O
23 9.3 L
24 9.0 V
4 5 8.8 V
6 9.3 O

VARIABLE STAR OBSERVATIONS Mar. 10 to Apr. 10 1912—Continued.

090425
W Cancri
Mo. Day Est. Obs.
4 8 8.8 S

093178
Y Draconis
3 22 12.2 Y
4 3 13.4 Y

093934
R Leo. Min.
3 10 9.4 O
13 9.0 O
13 9.0 Hu
4 6 10.3 S

094211
R Leonis
3 7 6.8 G
10 8.0 L
10 7.5 O
10 6.0 F
11 7.8 L
13 7.2 V
13 7.7 Su
14 7.7 L
14 6.5 G
17 7.4 Ha
18 6.3 G
18 6.6 F
19 7.4 L
19 7.2 V
22 6.7 F
22 6.9 O
23 7.4 L
24 7.0 Ha
27 6.9 F
29 6.0 G
30 6.4 O
4 2 6.5 Ha
3 5.9 G
4 6.2 Y
5 6.2 V
6 6.2 O
6 6.4 Ha

103769
R Urs. Maj.
3 7 11.0 G
10 11.0 F
11 11.3 L
13 11.4 J
13 11.0 Su
13 11.4 L
14 10.9 B
14 11.4 L
15 11.4 J
15 11.5 L
17 11.4 J
17 11.6 L
18 11.0 B
22 11.9 Y
22 11.0 B

R Urs. Maj.
Mo. Day Est. Obs.
3 22 11.0 F
22 11.0 G
22 11.6 J
23 11.7 L
24 10.8 F
26 11.0 J
4 4 12.3 Y
4 11.5 B

105517
R Crateris
3 10 8.0 F
18 8.8 G
18 8.8 F
22 8.6 F

110506
S Leonis
3 16 11.6 Y
22 11.6 Y
4 3 10.8 Y

121418
R Corvi
3 21 9.2 G
31 9.3 G

122001
SS Virginis
4 6 7.3 O

122532
T Can. Ven.
3 16 12.6 Y
4 3 11.6 Y

123160
T Urs. Maj.
3 10 7.5 O
13 8.2 J
13 7.8 Su
17 7.5 J
17 8.3 Ha
18 7.8 B
22 7.8 Y
22 7.3 O
22 7.4 J
24 8.0 Ha
25 7.5 B
30 7.3 O
31 7.4 J
4 3 7.8 Y
3 7.4 J
5 7.5 B
6 7.3 O
6 7.8 S

123307
R Virginis
3 22 10.5 O
25 11.3 Ha

123961
S Urs. Maj.
Mo. Day Est. Obs.
3 9 9.9 V
10 9.9 O
12 9.9 L
13 9.9 J
13 9.1 Fu
13 9.7 L
14 9.5 L
15 9.5 L
15 9.5 J
16 9.4 V
17 9.2 Ha
17 9.4 J
17 8.8 M
18 9.0 B
19 9.4 L
22 9.0 J
22 9.0 Y
22 9.2 O
23 9.3 L
24 8.9 Ha
24 8.9 V
25 8.5 B
26 8.6 L
28 8.8 G
30 9.0 O
30 8.7 J
4 2 8.6 Ha
3 8.3 Y
3 8.0 M
3 8.6 J
5 8.4 B
6 9.0 O
6 8.7 S
6 8.4 Ha

124606
U Virginis
3 22 10.1 O
4 6 8.9 O
6 9.0 Ha

132422
R Hydrae
3 8 6.0 G
10 6.2 G
10 6.5 F
11 9.3 L
19 6.5 L
20 6.6 G
22 7.0 F
24 7.0 F
25 6.8 L
26 7.1 F
31 6.9 G

132706
S Virginis
3 11 10.5 L
14 10.6 L
17 10.6 L
25 11.1 L

133273
T Urs. Min.
Mo. Day Est. Obs.
3 13 10.2 Fu

133633
T Centauri
3 10 8.8 G

134440
R Can. Ven.
3 10 12.0 O
22 11.7 O
4 8 11.2 O

141567
U Urs. Min.
3 13 9.9 Fu
13 9.8 J
15 9.7 J
16 9.7 J
17 9.7 J
22 9.3 J
30 9.2 J
31 9.2 J
4 4 9.2 J
6 8.1 S

141954
S Boötis
3 10 10.2 O
13 10.5 J
17 10.7 J
22 11.5 O
22 11.2 J

142539
V Boötis
3 10 7.0 G
12 7.9 L
13 8.0 L
14 8.0 L
18 7.5 G
18 7.5 F
19 7.9 L
22 7.6 F
23 8.0 L
24 7.8 F
26 8.0 F
4 3 8.1 G
6 8.0 S

142584
R Camelop
3 13 11.1 J
17 11.3 J
22 11.2 B
4 4 11.2 B

143227
R Boötis
3 11 7.5 L
12 7.5 L
13 7.7 L
15 7.8 L
19 7.7 L
26 7.9 L
4 6 7.9 O
6 8.4 S

151731
S Cor. Bor.
Mo. Day Est. Obs.
3 21 7.6 G
4 8 8.0 O

153378
S Urs. Min.
3 10 10.4 L
12 10.4 L
13 10.6 Fu
13 10.6 L
14 10.7 L
15 10.6 L
19 10.7 L
21 10.7 L

154428
R Cor. Bor.
3 10 9.6 J
13 9.4 J
14 9.3 Y
16 9.1 J
17 9.0 J
20 7.2 G
22 8.4 J
24 7.9 F
26 8.0 F
4 4 7.9 Y
4 7.5 J
6 7.4 O
8 7.4 O

155847
X Herculis
3 10 6.4 L
12 6.4 L
14 6.4 L
15 6.4 L
23 6.4 L

162119
U Herculis
3 14 9.2 Y
21 8.2 G

163172
R Urs. Min.
3 20 10.2 B
30 9.9 O
4 3 9.7 B
6 10.4 F

163266
R Draconis
3 13 7.1 J
14 7.3 G
16 7.1 J
17 7.1 J
21 7.0 G
22 7.2 O
22 7.1 B
22 7.0 J
22 6.9 Y

VARIABLE STAR OBSERVATIONS Mar. 10 to Apr. 19, 1912—Continued.

R Draconis

Mo.	Day	Est.	Obs.
3	29	7.0	G
	30	7.0	O
	31	7.2	J
4	3	7.0	B
	3	6.9	G
	3	7.4	Y
	4	6.7	J
	6	7.1	O
	6	7.4	S

164715
S Herculis

3	10	8.5	J
4	4	9.0	J

170215
R Ophiuchi

3	10	7.1	J
	10	7.2	G
	14	7.0	L
	17	7.1	L
	18	7.2	F
	19	7.2	G
	23	7.4	L
	26	7.6	F
	27	7.8	L
4	4	8.3	J

181136
W Lyrae

3	14	10.0	Y

184205
R Scuti

3	14	5.8	G
	19	5.9	G

193449
R Cygni

Mo.	Day	Est.	Obs.
3	7	9.8	F
	10	9.4	G
	10	9.9	L
	10	10.0	F
	11	9.9	L
	14	9.8	L
	18	9.8	F
	19	9.7	S
	19	10.1	L
	24	10.0	F
	25	10.1	L
	26	10.0	F
	29	9.8	G

194048
RT Cygni

3	6	7.8	F
	10	8.1	F
	10	8.0	L
	10	7.0	G
	11	7.9	L
	14	8.2	L
	18	7.4	F
	19	7.3	G
	24	8 3	F
	25	8.5	L
	26	8.2	F
	29	8.2	G

184248
TU Cygni

3	7	10.0	F
	10	10.3	F
	24	9.3	F
	26	9.3	F

194632
X Cygni

Mo.	Day	Est.	Obs.
3	11	10.8	F

195849
Z Cygni

3	21	9.0	G

200938
RS Cygni

3	10	8.9	J
	29	8.8	G
4	4	8.9	J

201008
R Delphini

3	10	11.5	J

201130
SX Cygni

3	14	11.0	Y

201647
U Cygni

3	10	6.8	G
	10	7.8	L
	10	7.6	J
	11	7.8	L
	14	6.8	G
	14	7.8	L
	18	6.9	F
	19	7.9	L
	19	6.9	G
	20	7.8	L
	24	7.4	F
	26	7.5	F
	29	7.2	G
4	4	7.8	J

203816
S Delphini

Mo.	Day	Est.	Obs.
3	14	9.7	Y

204016
T Delphini

3	14	11.8	Y

205923
R Vulpeculae

3	10	8.2	J

210868
T Cephei

3	10	10.5	L
	11	10.6	L
	13	10.0	J
	13	10.5	L
	14	10.4	L
	15	10.5	L
	17	9.9	J
	19	10.4	L
	21	10.2	L
	24	10.0	L
	25	9.8	L
	27	9.5	B
	30	9.4	B
4	3	9.8	J
	8	9.6	S

213044
W Cygni

3	14	6.0	L
	25	6.1	L

213678
S Cephei

3	13	8.5	J
	17	8.6	J
	22	8.5	J
	30	8.9	B
4	4	8.9	J
	8	8.5	S

213843
SS Cygni

Mo.	Day	Est.	Obs.
3	10	11.9	J
	14	9.6	J
	14	10.4	Y
	21	8.4	G
	24	8.4	F
	26	9.0	F
	29	10.7	G

213937
RV Cygni

3	29	7.2	G
	31	7.1	G

223841
L Lacertae

3	14	12.4	Y

230759
V Cassiopeiae

3	10	10.0	G
	17	10.1	J
	18	10.5	F
	18	10.5	G
	26	10.8	F

235939
SV Androm.

3	22	9.0	Y

064932
Nova Gemin.

3	16	6.2	G
	18	6.5	G
	19	5.2	L
	19	5.2	Fu
	19	5.2	Su
	20	5.2	Su
	21	5.3	L
	22	4.8	Fu
	22	4.9	Su
	22	4.6	L
	23	4.4	L
	24	4.5	L
	25	4.8	L
	26	5.3	L

No report has yet come in of any observation of the occultation of Venus on April 15.

COMMUNICATIONS QUESTIONS AND ANSWERS.

[This department is designed especially for the use of amateurs. Beginners are invited to send in their puzzling questions. The editors will try to see that answers are given to reasonable questions, but will not hold themselves responsible for the correctness of the views expressed in the communications which may find place here. All communications should be brief.]

Lower Limit of Magnifying power.—The account, in the April issue of POPULAR ASTRONOMY, given by Mr. S. C. Hunter, of his visit to the U. S. Naval Observatory, is full of interest. But, lest his expression of disappointment at finding no eye-piece for the 26″ equatorial, giving a power lower than 140, might mislead some readers in regard to the completeness of the

observatory's equipment, and also in regard to the possibilities of low magnifying power in large telescopes, it may be fitting to call attention to a matter which Mr. Hunter has overlooked. The diameter of the pupil of the normal eye is given as $\frac{1}{5}$ of an inch. No pencil of light-rays larger than this can wholly enter the pupil. The diameter of rays emerging from the eye-piece of a telescope is found by dividing the diameter of the objective by the power of eye-piece upon the given telescope. As the Washington objective is 26 inches in diameter, we find that when we divide it by less than 130, the resultant is larger than $\frac{1}{5}$. A power of 130 will give an emerging pencil of rays just $\frac{1}{5}$ of an inch in diameter, for $\frac{26}{130} = \frac{1}{5}$.

Now, as the pupil of the eye often contracts to less than $\frac{1}{5}$ of an inch, the power of 140 is practically the lowest available power which can be applied to that instrument. So far as the power applied should fall under 130 diameters, to just that degree would the available light-grasp of the objective be decreased. To receive the benefit of the full aperture, the lowest power applied to the 40″ Yerkes telescope can not be under 200.

The lowest power of a 5″ telescope, like Mr. Hunter's, must not be less than 25. Experiments by the writer convince him that it is unwise to carry the magnifying power down to the $\frac{1}{5}$″ limit. I have been recently making several low powers for my 6″ Clark telescope: the lowest is 31. But, as this brings the pencil of rays coming to the eye, almost to the $\frac{1}{5}$″ limit, the eye is rarely held so perfectly against the pencil as to allow all of its rays to enter the pupil. A power of 40 on the 6″ will show with more distinctness the fainter stars, for the eye receives through it the full pencil of rays from the objective.

TILTON C. H. BOUTON.

Hudson, N. H., April 2, 1912.

The Ursa Major Meteors.—It may be of interest to some of your readers who observe meteors to know that the Ursa Maiorid shower of April 9-12, with a radiant point, as given in "Astronomy for Amateurs" by John A. Oliver, of 184° R. A. +59° Dec., was observed here April 10, 11, and 13, April 12 being cloudy. I observed all three nights, and was assisted on April 13 by Mr. Monroe.

On April 10, observations were begun at 8.00 E.T., and ended at 11:05. During this time, 11 meteors were seen, but only four from the desired radiant. These four gave its position at $11^h\ 41^m$ +56°.2. On April 11, it was cloudy in the early part of the evening, so that observations were not started until 9:20, continued for a few minutes, and stopped. They were begun again at 10:15, and continued until 11:00. During this time eight meteors were seen, three of which were from the desired radiant. These gave the same position as the night before. On April 13, observations were begun at 8.30, and stopped at 9:30. In this time, only three meteors were seen, none from the desired radiant.

The meteors were in general faint and slow, leaving slight trains. The brightest meteor seen on the three nights was on April 13, at 8:45. It started at $8^h\ 55^m$, +50°, and ended at $5^h\ 54^m$ +41°. Its magnitude was 0.0; duration, 5ˢ. It left a long, yellow, train. This meteor was not of the desired shower.

EVERETT T. KING.

Sigurd Enebo, Discoverer of the "Nova Geminorum", and his Observatory.—The Norwegian astronomer, Mr. Sigurd Enebo, has a very simple observatory at Domaas, Norway. From here he discovered, on the night of March 12-13, the Nova Geminorum, which now has made his name famous. Singularly enough, Herschel, on this same date, in 1781 discovered the planet Uranus—also in the constellation of Gemini.

Mr. Enebo's "observatory" is of the home-made variety, and consists simply of a square hole dug into the ground, down to which he descends to watch the skies on every clear night. In the day time it is covered up by a trap door and resembles an old abandoned well much more than an astronomical observatory. Whether he received the idea for his "Observatory" from Tycho Brahe's "Uraniborg" or not shall be be left unsaid; but in his circumstances it has proved to be practical, and he certainly has made good use of it.

Sigurd Enebo was born in 1866 at Lesjeskogen, Norway, where also is situated his farm Domaas, (which means "Dome-ridge"—a fitting name indeed for the home of an astronomer, although this one does not yet boast of any dome-bedecked observatory). He chose for his profession that of a country school teacher, and for several years he taught school during the day, and cultivated his passion, astronomy, during the night. In his spare moments he studied, without any outside help, the higher mathematics and the French language,—no doubt in order to study the "Celeste Mécanique" in the original tongue.

Mr. Enebo is, therefore, a self-made and self-taught astronomer. His speciality is the watching and the recording of variable stars, and he is also a skilful computer of cometary elements and orbits. Several valuable essays and articles from his pen have appeared in the daily as well as the astronomical papers and magazines of Europe.

In 1906 he captured the "Lindemann's Prize" of the "Astronomische Gesellschaft", and since 1908 he has received a yearly stipend from the Norwegian government, in order that he may devote his entire time to astronomy.

It is to be hoped that the necessary funds for the erection of a modern equipped observatory will soon be obtained by Mr. Enebo, so that the science of astronomy may be benefitted by the observations of this zealous observer, made under more favorable circumstances.

J. Rode Jacobsen.

2814 N. Albany Ave., Chicago, Ill.

GENERAL NOTES.

Mr. Arthur Robert Hinks of the Cambridge Observatory has been awarded the Gold Medal of the Royal Astronomical Society for his determination of the Solar Parallax from the observations of Eros. The address of presentation was made on Feb. 9, 1912, by the president of the Society, Mr. F. W. Dyson, Astronomer Royal of England.

Mr. John A. Parkhurst of the Yerkes Observatory has been advanced to the rank of assistant professor in the University of Chicago. Mr. Parkhurst is carrying on extensive research in photometry. He is just completing the determination of the visual and photographic magnitudes of all the stars within seventeen degrees of the north pole which are of the 7.5 magnitude or brighter.

A Medal to Professor Brooks.—The comet medal of the Astronomical Society of the Pacific has been awarded to Dr. W. R. Brooks, Director of the Smith Observatory and Professor of astronomy at Hobart College, Geneva, N. Y., for his discovery of the Brooks comet of 1911. This is the tenth medal received by Dr. Brooks from this society, including the first medal which it awarded to any astronomer.

Professor Abbot Lawrence Rotch, founder and director of the Blue Hill Meteorological Observatory and professor of meteorology at Harvard University, died on April 7, aged fifty-one years. He has bequeathed to Harvard University the Blue Hill Meteorological Observatory, which he established in 1885 and had directed up to the time of his death. He has further provided an endowment fund of $50,000. (*Science* April 12 and 19, 1912.)

Mr. C. E. Adams has been appointed government astronomer for the dominion of New Zealand (*Science*, April 19, 1912.)

Mr. F. G. Figg, formerly first assistant at the Colonial Observatory, Hongkong, has been appointed director of the Mauritius Observatory (*Science* Mar. 22, 1912).

M. Bigourdan, of the National Observatory, Paris, has been elected president of the Paris Bureau des Longitudes for the present year. M. Baillaud becomes vice-president and M. Andoyer, secretary. (*Science* Mar. 29, 1912.)

Parallax of Nova Lacertae 1910.—In the *Astrophysical Journal* for March 1912 Mr. Frederick Slocum gives the results of a determination of the parallax of Nova Lacertae, from the photographs taken with the 40-inch telescope of Yerkes Observatory. He obtains for the parallax

$$\pi = + 0''.013 \pm 0''.014$$

The parallax is thus uncertain by its whole amount but it is surely exceedingly small. If this value be correct, the outburst observed in 1910 really occurred 180 years ago.

The Great Telescope for the Allegheny Observatory.—From a newspaper clipping, enclosed in a private letter from Pittsburg, we learn that the 30-inch refracting telescope for the Allegheny Observatory is practically finished except the lenses, which are to be ground and polished at the optical works of Dr. John A. Brashear and are expected to be finished in about nine months.

As showing the convenience of the mechanism of the telescope and dome the reporter says: "Dr. Schlesinger touched an electric controller and the great tube 50 feet long, with an aperture at the sky end, where the great lens is to fit, 30 inches in diameter, swung swiftly and noiselessly up and down and around, pointing to any desired part of the heavens with accuracy greater than that of the most delicate rifle. He touched another controller, and the great dome, weighing 70 tons, commenced revolving at the rapid rate of a revolution a minute; another controller, and the floor, weighing 22 tons, rose

and fell like a great elevator, until all sense of direction and altitude were lost, and the observer could not tell north from south nor how far he would have to fall to reach the ground. Everything about the telescope is made of iron, so that all expansion due to heat and cold will be the same, and not throw the mechanism out of adjustment. Necessarily no heat may be admitted to the dome, and during the long 14-hour winter nights, which are best for observations because of the clearness of the atmosphere, the observer must sit in the cold, surrounded by iron which would freeze him fast were he to touch his bare hand to it. Dr. Schlesinger says that he has spent nights in domes where the thermometer stood at 28° below zero, and he has an Eskimo costume, such as is used by arctic explorers, for that purpose."

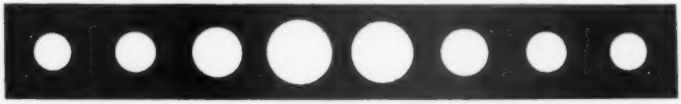
The telescope has been in the process of construction for 10 years. It is the gift of the Thaw family, to the memory of William Thaw, and cost more than $100,000.

An Observatory near a Volcano.—There came to our notice recently a pamphlet which was published some time ago containing a description of observations and also containing some photographs made of Halley's comet under rather unusual conditions. The instruments necessary for the observations were transported from France to the island of Teneriffe under the direction of Jean Mascart. A temporary observatory was established on one of the high mountain peaks on the island at an elevation of about one and two-thirds miles. It was situated at the same place to which Piazzi Smyth had gone in 1858 for the purpose of carrying on his studies in spectroscopy. This location was found exceedingly favorable, being situated normally above the clouds and having the ocean as the horizon on every side. It would doubtless be of great value to the progress of the science of astronomy if a permanent observatory could be maintained there, because at ordinary altitudes clouds are continually interrupting observational work.

Sir Isaac Newton's Apple-tree.—In the minutes of the Annual General meeting of the Royal Astronomical Society, Feb. 9, 1912, it is recorded "that the Society had received an interesting relic as a present from Mr. C. W. Walker, of Burwash, Sussex, this being a small log from the apple-tree in the garden of the Manor House at Woolsthorpe, from which it is said that Newton saw the apple fall, and was thereby led to certain thoughts on the subject of gravitation."

In *The Observatory* for March 1912 the history of this relic is given as related in a letter from Mr. Walker. "He says that his father, who was born in 1807, was at school when he was 10 or 12 years old with the rector of Stoke, Lincolnshire, named Pearson. One night there was a severe storm of wind and in the morning news came that Sir Isaac Newton's apple tree had been blown down. Mr. Pearson and some of the boys at once set out for Woolthorpe, which is not far from Stoke. When they arrived they saw the tree lying on the ground. It had been propped up all around for very many years, and it appeared that the wind had blown it over the props. Mr. Walker, senior, says he did not know by whose authority Mr. Pearson acted, but he got a saw from somewhere and sawed a good many logs of wood from one of the branches, and it is one of these which is now in the possession of the Society, Mr. Walker, senior, having preserved it carefully throughout his life and handed it down as an heir loom."

Oppositions of Mars 1901 to 1950.—In *L'Astronomie* for February 1912 are given the accompanying illustrations and data concerning the oppositions of Mars during the first half of the twentieth century. The illustrations were prepared by Mr. F. Baldet from the data given in the *Astronomische Nachrichten* No. 4379 by Mr. Enzo Mora, who there gave similar data for all the oppositions from 1800 to 1899. The illustrations put before the eye in a very graphic way the variation in apparent diameter of Mars at successive oppositions. The most favorable oppositions yet to come in this half century will be in 1924, 1939 and 1941.



Year	1901	1903	1905	1907	1909	1911	1914	1916
Opposition	Feb. 22	Mar. 29	May 8	July 6	Sept. 24	Nov. 25	Jan. 5	Feb. 9-10
Perigee	Feb. 22-23	Apr 2-3	May 16	July 13	Sept. 18	Nov. 17	Jan. 1	Feb. 9
Dist.Perig.	0.677	0.638	0.537	0.408	0.389	0.511	0.622	0.675
Diam.	13″.8	14″.7	17″.4	22″.8	24″.0	18″.3	15″.0	13″.9
Max.Br.	20.9	24	39	79	90	45	27	21

Year	1918	1920	1922	1924	1926	1928	1931	1933
Opposition	Mar. 15	Apr. 21	June 10	Aug 23	Nov. 4	Dec. 21	Jan. 27	Mar. 1
Perigee	Mar. 18	Apr. 28	June 18	Aug. 22	Oct. 26	Dec. 15	Jan. 25	Mar. 3
Dist.Perig.	0.661	0.583	0.456	0.373	0.459	0.585	0.662	0.675
Diam.	14″.1	16″.6	20″.5	25″.1	20″.4	16″.0	14″.1	13″.9
Max.Br.	22	31	59	100	60	32	22	21

Year	1935	1937	1939	1941	1943	1946	1948	1950
Opposition	Apr. 4	May 19	July 23	Oct. 10	Dec. 5	Jan. 13	Feb. 17	Mar.23
Perigee	Apr. 12	May 27	July 27	Oct. 3	Nov. 28	Jan. 10	Feb. 17	Mar 27
Dist.Perig.	0 621	0.509	0.388	0.410	0.540	0.639	0.678	0.650
Diam	15″.0	18″.4	24″.1	22″.8	17″.3	14″.6	13″.8	14″.4
Max.Br.	26	44	90	79	39	25	20	23

Variation in the apparent size of the planet Mars for the oppositions from 1901 to 1950. Drawings by M. F. Baldet in *L'Astronomie* Feb. 1912.

A Quick Drying Backing Mixture for Plates.—A formula for a backing mixture which dries within a minute or two of applying to the plate is given in the current issue of "Photographische Korrespondenz", by Dr. Domek, and may be worthy of mention for use when ready-backed plates are not at hand, or when an odd size of plate requires to be backed. Agfa. Sudan III (15 grs.) is dissolved in 2 ozs. of ether, allowed to stand over night, and after filtering, addition made of 50 minims of linseed oil. The dye solution is mixed with 1 oz. 6 per cent collodion, and addition finally made of 1 dr. of 1 per cent solution Kristall Violet of Meister Lucius and Brüning, dissolved in a mixture of equal parts alcohol and ether. This dark red solution is simply brushed over the back of the plate, which is left for a minute or two for the coating to become hard before placing in the slides. After exposure, the plate is put for a minute or two in plain water, when the collodion film quickly comes away; but there is no real need to remove the backing before development, as it is completely transparent, and does not in any way disturb the judgment of the density of the negative (*Brit. Jour. Photog.* Mar. 12, 1912).

A Good Honest Method.—In Punch for February 21, one of the illustrated dialogues reads as follows:—

"Which of these clocks is right ?"

"I dont know. We've five clocks. When we want to know the time we add 'em together and divide by five, and even then we're not certain."

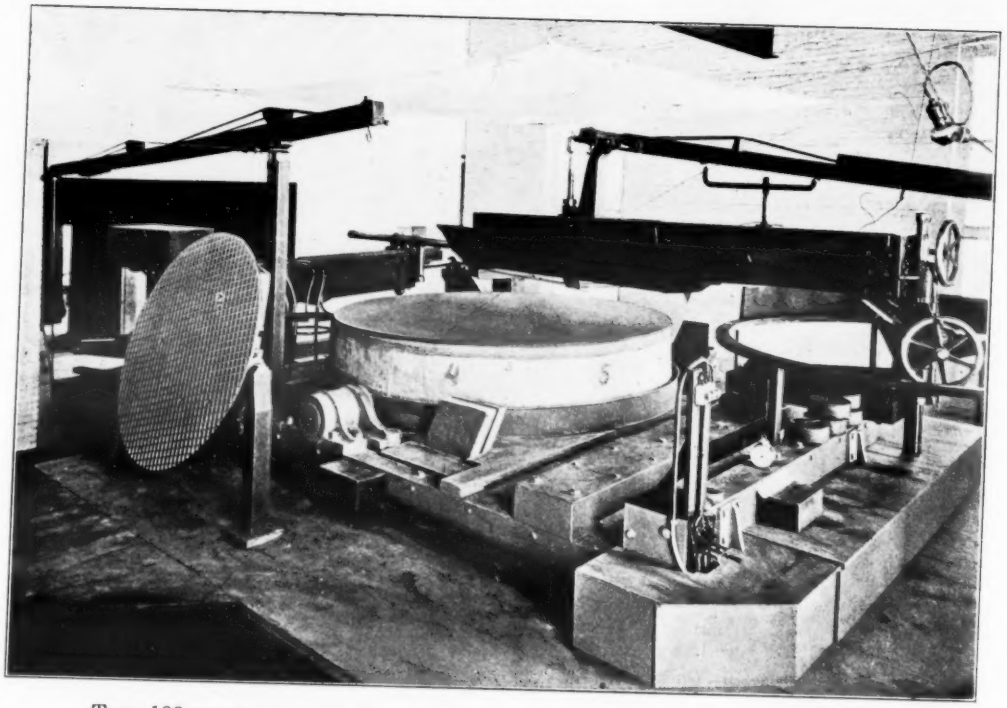
It is a good honest scientific method; why should it seem so humorous in practical life? Is it because in science the last half dozen words are usually suppressed? (From an Oxford Note-Book in *The Observatory* March 1912.)

The 150-foot Tower Telescope of the Mount Wilson Observatory.—The following is from the Annual Report of the Director for 1911:—

At the time at which the last annual report was written the two lenses for use in the tower telescope had just been received. They were of triple construction and designed to reduce the effect of chromatic observation to a minimum. A careful examination of these lenses in the optical testing-rooms in Pasadena indicated the presence of strong astigmatism and considerable spherical aberration, and accordingly they were returned to their makers for additional figuring. On further examination it was found that one of the components in each lens had indices of refraction unsuited for the purpose in view, and the attempt was made to procure new disks of glass of satisfactory indices. After a number of efforts in this direction without success, it was decided to give up the triple form of construction and resort to the ordinary doublet type. New lenses of this sort corrected visually were received in July of this year and tests show a marked improvement over those tried previously. The 8-inch lens for use in the spectrograph has been accepted, but the image forming objective of 12 inches aperture is still found to be subject to considerable zonal errors and has been returned to the manufacturers for further retouching.

With the exception of the image-forming lens the 150-foot tower is now complete in all of its essential features, and in case of serious delay in the completion of the 150 foot objective, the lens now in use with the 60-foot tower will be employed in order to gain the advantages of the more powerful spectroscopic apparatus of the larger tower.

PLATE XII.



THE 100-INCH DISK ON THE GRINDING MACHINE, READY FOR POLISHING.

The 100-inch Telescope.—From the same report above-mentioned we gather also the following facts about the 100-inch reflecting telescope which is in the process of construction:—

In view of the difficulty experienced by the French Plate Glass Company in securing a thick disk of 100-inches aperture which should be free from air bubbles and flaws, it seemed advisable in the autumn of 1910 to begin work upon the disk already received and temporarily laid aside. An inspection of this disk had shown that while there were well defined sheets of air bubbles running through the body of the glass, they did not approach the surface so closely as to interfere with securing a perfectly paraboloidal figure. Furthermore, the glass as a whole seemed to be very firmly knit together, in spite of the presence of the bubbles. Since under these conditions the only obstacle to the perfect success of the disk as an astronomical mirror would lie in the presence of strains in the glass which would prevent it from maintaining its figure under different conditions of temperature, it appeared well worth the relatively moderate cost of the necessary optical work to investigate this question. By the kindness of the French Plate Glass Company the Observatory is permitted to do this work on trial, payment for the disk being conditioned upon its proving suitable for use as an astronomical mirror.

The process of figuring the disk, although delayed by illness on the part of those engaged in the work, has been continued steadily, and at the present time the fine grinding of the spherical surface has been completed. As soon as the polishing is finished a series of tests will be undertaken to determine the character of the figure at different temperatures. So far as it is possible to judge, no changes have taken place in the flaws contained in the glass during the severe pressure put upon it by the process of rough grinding. The disk is being figured with a ratio of focal length to aperture of 5 to 1.

While this work is being carried on at Pasadena, the French Plate Glass Company is continuing at St Gobain the attempt to cast a disk which shall be free from flaws and air bubbles. The chief difficulty encountered in recent trials has been that of annealing in such a way as to keep the temperature of the entire body of glass uniform. Owing to this cause a second disk cast early in this year broke in the annealing oven. In the course of their experiments the St. Gobain company have succeeded in producing a flawless disk 100 inches in aperture and 20cm. thick. It is possible that in case of necessity such a disk could be employed for the 100-inch telescope, provided it were figured in place upon the support system with which it was to be used finally.

In the mean time the work upon the design of the mounting has been carried on actively and the essential features of the design have been thoroughly worked out. The site for the telescope has been graded, several small buildings for housing the machinery employed in the work and a few of the smaller piers have been erected. A large amount of material for the main pier has been collected ready for use this coming summer.

The Great Star Map, by H. H. Turner, D. Sc., D.C.L., F.R.S., Savilian Professor of Astronomy in the University of Oxford, 1912, published by E. P. Dutton & Co., New York. Price $1.50 net. This is a very interestingly written little volume descriptive of the great project, which was undertaken twenty years ago, and which is not yet completed, of producing a photographic map ("Astrographic Chart") of the entire heavens which should include all the stars which can be seen with the aid of a small telescope, together with a catalogue of accurate positions of stars down to the eleventh magnitude. No

one could be more competent to write a book upon this subject than Dr. Turner, for he was present at the initial meeting of the Permanent Committee which undertook general supervision of the project, and undertook for the Oxford Observatory one of the zones into which the sky was divided in the apportionment of the work to the various coöperating observatories. His observatory has completed its part of the work, aside from the publication of the chart plates, which is being done at Paris. The style in which the book is written may be appreciated from the following abstract: "Let us now consider what is to be the outcome of this immense piece of work. What are we likely to learn from these millions of measurements? As already stated, the interest will come when it is repeated —in the study of the movements of the stars; which are so minute that, as a rule, at least a century is required to discern them even by our improved modern methods. The movements are not really slow; we may take the velocity of our earth in its annual journey round the sun—about 20 miles a second—as a fair sample of the velocities of the stars. But our great journey from side to side of the sun (nearly 200,000,000 miles across) would seem a minute movement to the nearest star, and to the great majority would be imperceptible. This is however not the only movement of the earth; the sun himself is moving and we partake of that motion also. It is not a circling or oscillatory motion, but is in the same direction year after year, so far as we can at present ascertain, the distance traversed each year being about 400,000,000 miles. One year's journey is therefore scarcely more perceptible from the distant stars than the circling movement of the earth; but as year follows year the successive steps add together, and the cumulative effect becomes ultimately perceptible even to very distant stars. Now all the stars are moving in this way—persistently—year after year. Hence, though the movement be imperceptible, by waiting ten years or twenty or a century we ultimately perceive the movements of many of them. The more distant require even longer —how much longer we cannot yet say; this is one of the questions on which we hope to get some light by the work on the Great Star Map and its successors. Our knowledge will grow; we shall find that after ten years a certain percentage of the stars have moved; after twenty, new movements previously undetected or uncertain will be added; after thirty, more still, and so on; and by watching the run of the sequence we may even be able to predict what will happen in longer periods not yet reached, though this extrapolation has its risks".

In the fourth chapter entitled "Some Incidents of the Work" the writer discusses among other things the Eros campaign, magnitude equation, and what happens to new stars.

The Sun:—By Charles G. Abbot, S. M., Director Smithsonian Astrophysical Observatory, pp. XXV + 448. D. Appleton and Co. 1911.

This book illustrates the great strides which solar physics has been taking even in the short time since the last edition of Young's work of the same title. In comparing the new work with its predecessor, it would perhaps be too much to expect that happy faculty for grasping essentials and the judicious weighing of evidence in moot questions which distinguished Professor Young as one in a thousand. The present treatise can hardly equal the earlier one in this respect, but it records concisely a great mass of new observational material. In the matter of causes for the observed phenomena and as a critique of hypotheses, the book suffers by comparison with the recent work, "Les théories modernes du soleil," by J. Bosler of the Observatory of Meudon, which is especially strong

in this respect. But while Abbot is not always entirely fair to rival hypotheses which run counter to his own, and has permitted himself some rather risky speculations, we need not question his right to speculate. One of the great needs of science today is not so much more observations, for in many departments of science we are fairly smothered with facts, which have been heaped up and left unelaborated, with very little effort to get them to divulge their meaning. Science today should be more than a "museum catalog." It must go farther, enter the realm of causes, and become a philosophy. Therefore there is no need to find fault with the author in that he has "set down several hypotheses which can be regarded as only slenderly founded;" but we have a right to ask that the same privilege shall be extended to others, and that hypotheses shall not be erected into barriers against further consideration of questions which ought to remain open.

Among the hypotheses which are either proposed or endorsed, but which must be regarded as "only slenderly founded," may be mentioned the supposition that the photosphere is not a radiating billowy surface of incandescent cloud, giving out a continuous spectrum, but that its light results from the coalescing of bright spectral lines, broadened by great pressure and emanating from considerable depths of an unclouded and purely gaseous sphere. Another doubtful hypothesis is the view that the earth receives from the sun a diminished radiation at the epoch of maximum sunspots.

The supposition (p. 276) that the sun has been growing hotter through the geologic ages, but that its much greater size compensated for a lower temperature to a considerable extent at remote epochs, and produced mild climates at the poles when the solar angle was great (though how this could be a true cause as late as the Cenozoic remains a puzzle,) may be referred to the geologists, along with geographic, atmospheric and other changes which have been invoked to account for the facts; but the idea is not new, having been proposed many years ago by Faye, nor is it in agreement with the author's conclusion (on p. 403) that "stars in general give much more light in proportion to their masses than does the sun," and that "for the stars generally a smaller density than that of the sun" is predicable, a relation which would suggest *greater* brightness in the more expanded sun.

The reason adduced for a feebly radiant Paleozoic sun is the operation of Lanes law; but this law merely asserts that in a contracting gaseous sun, the central regions must be getting hotter. The rate of transference of central heat to the outside may progressively diminish, so that the outside gets no hotter, or the effective radiating layer may even be cooler than before. Terrestrial climates have usually been found by the geologists, on the whole, much warmer in the earlier ages. Houghton developed a temperature time scale of this sort from the progressions of plant and animal life. The sections devoted to recent spectroscopic and spectroheliographic advances are crowded with new facts of the greatest interest.

Hale's discovery of the magnetic field in sunspots, the modes of investigating spectra, especially sun-spot spectra, by a study of the Zeeman effect on individual lines, and by comparisons with the spectral modifications induced by electric and temperature changes which are now at command in the electric furnace, the mutual interaction of solar and stellar studies—all of these, in addition to and in conjunction with former methods, open a way to promising fields of research. Ample credit is deservedly given to these great new departures. Hale's discovery of the swifter and nearly constant rotation of the elevated hydrogen floculi in all latitudes indicates that the sun's atmosphere has an upper layer, somewhat analogous to the elevated isothermal layer of the earth's atmosphere, where causes of disturbance are much reduced.

Notice is taken of Pringsheim's electrical explanation of the great velocities in prominences, founded on Stark's measures of velocities in canal rays. Miller's demonstration of a repulsive force between coronal streamers might have been added to this evidence.

Another admirable suggestion is that of Wood, which embraces both the polarization of the corona and the appearance of its spectrum. The last, as noted by Lockyer, consists of innumerable bright bands; and fluorescent light from metallic vapors proves to be similarly banded and polarized to the same extent as that of the corona which thus resembles in many ways the fluorescent phenomena discovered by Wood.

These are noteworthy additions to the already long list of possible conjectural explanations of the corona, and hold out the hope that we may soon understand this mysterious and complicated aggregation of scintillating dust, and glowing or fluorescing vapor—this complex of filaments and sheets of ions in electric or magnetic flow.

The chapter on the storing of energy from the sun's rays by plants concerns important chemical and physical problems, and is succeeded by one on the utilization of solar energy which enters more extensively than other parts of the book into matters of history. The conclusions may be commended to inventors of solar engines.

Less satisfactory is the treatment of the solar constant which is mainly a description of Abbot's own work. Pouillet's etimate of this quantity, which happens to very nearly coincide with his own, is described at some length, but one looks in vain for even the mention of the fact that many other investigators have devoted themselves to this problem, and with quite different results. Some omissions are unavoidable in a work which attempts to cover an extensive subject in small compass, but this does not excuse the suppression of inconveniently conflicting evidence. We note also in other places some historical inaccuracies. The book closes with a concise survey of the entire field of astrophysics.

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